2019 National Cave and Karst Management Symposium

7 – 11 October 2019

Bristol, Virginia, United States of America

Organized under the Auspices of the National Cave and Karst Management Symposium

Cave and Karst Grant Program

The Cave Conservancy of the Virginias (CCV)
is looking for Grant Proposals

The CCV is looking for proposals seeking funding for cave and karst related projects in Virginia or West Virginia or the adjacent areas to support:

- conservation efforts to protect cave and karst resources
- research projects to promote new discoveries in cave and karst environments
- education programs to disseminate knowledge on cave and karst systems.

Proposal submission deadlines are March 1 and October 1.

Guidelines for eligibility and proposal preparation are available at the following website: **https://caveconservancyofvirginia.org/**. If you have any question, please contact the CCV Grants and Awards Committee Chair, Maria Perez, at **maria.perez@mail.wvu.edu**

Examples of recently funded projects

- Assessing the Trophic and Climate Change Resilience of Stygobromus Tenuis Potomacus. ($14,495)
- Assistance to purchase and protect Robbins Rift Cave. ($8,000)
- Conservation Assessment of Crangonyctid Amphipods. ($15,600)
- Dye Tracing in Slussers Chapel Conservation Site. ($4,465)
- New River Cave Trail and Improvements. ($2575)
- Parallel Evolution in *Gammarus minus* Cave Populations. ($13,664)
- Phylogeography of two subterranean amphipod species. ($10,990)
- Publication and Distribution of the Virginia Cave Owners Newsletter. ($1,200)
- Sinkhole cleanup project 2016 Fall VAR. ($700)

Welcome to Bristol and NCKMS 2019!

We are so happy you could join us for the 2019 National Cave and Karst Management Symposium. We have a busy and fun-filled week planned. The twin cities of Bristol Virginia and Tennessee reflect the rich cultural and economic history of the Appalachians, and serve as the gateway to the complex and highly biodiverse karst areas of the Mountain Empire, the name given to southwestern Virginia and northeastern Tennessee by locals. The Birthplace of Country Music, Bristol is also home to many restaurants and venues that conference attendees may explore.

With over 55 abstracts submitted this year, we have a lot of content. A central theme of this year's NCKMS will be cave and karst management on private lands. In the east, the vast majority of caves are privately held, and their conservation depends on the stewardship of individual citizens and private conservancies. During the conference, we will highlight the achievements and approaches of numerous cave conservancies. Many of you attended pre-conference caving trips to conservancy properties and/or the *Lirceus* excursion with Jerry Lewis, and we hope you had fun and maybe even have gained a little useful knowledge.

Sessions kick off Tuesday morning with Dave Culver describing the conservation legacy of Dr. John "Captain Karst" Holsinger, followed by several talks about cave and karst conservation in Virginia before spreading geographically across the Eastern U.S. with a focus on the efforts of private cave conservancies. Tuesday night we're holding the Howdy Party at Bristol Station Brewery, with complimentary beverages, hors d'oeuvres, and live music. We're running shuttle buses from and to the hotel, so no one need drive. Those seeking a larger evening meal should patronize one of downtown Bristol's fine restaurants, all an easy walk from the shuttle drop off at the Brewery. Shuttles will run until midnight, but you might want to consider turning in at a reasonable hour since Wednesday promises to be a long, fun day – meeting for departure from hotel at 7:45.

On the Wednesday field trip you well have the opportunity to:

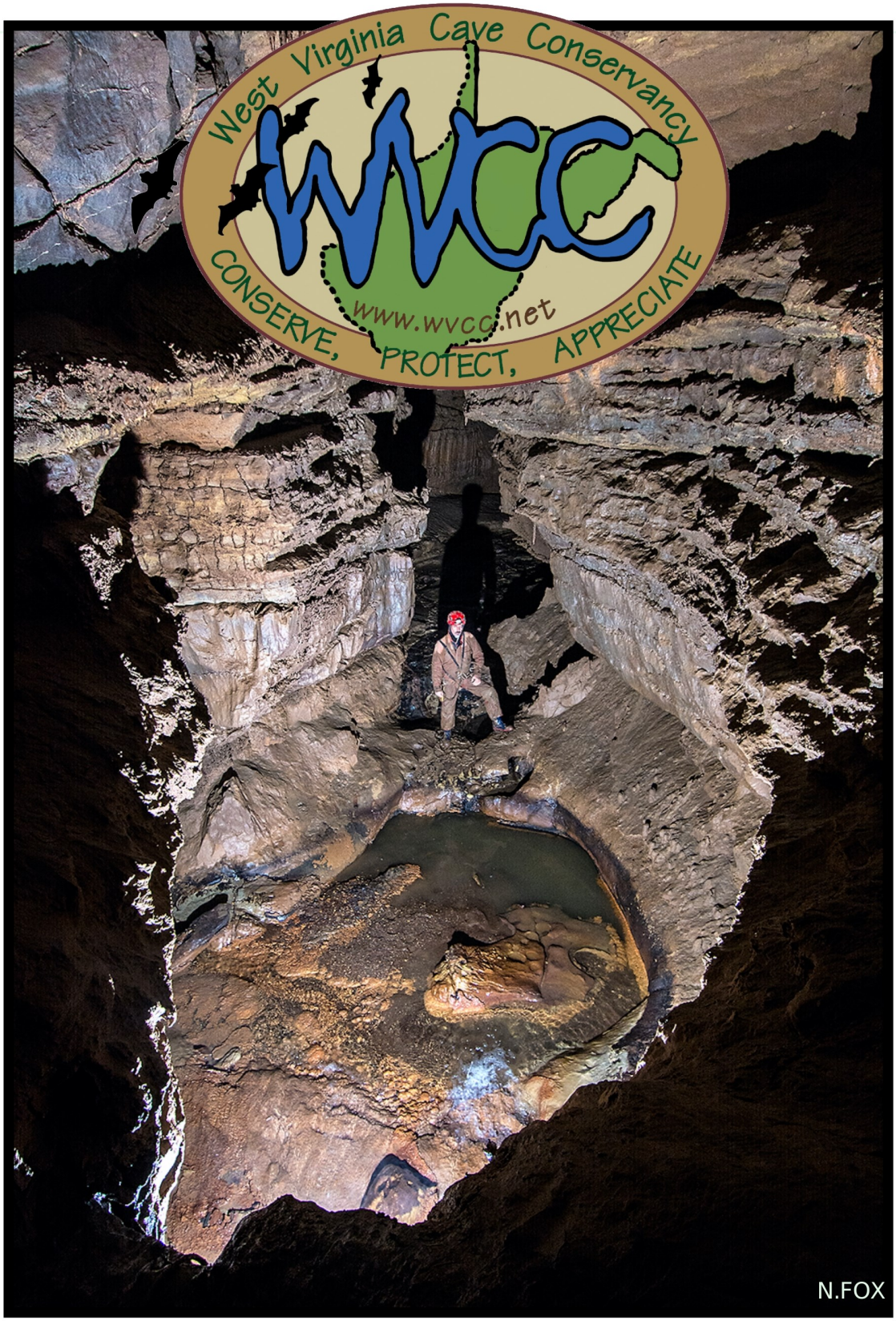
- hike or ride on the chair lift at Natural Tunnel State Park – train through a cave, 'nuff said.
- tour Gap Cave, Cumberland Gap National Historical Park – a great cave and site of an innovative public–private partnership between the National Park Service and the Cave Research Foundation.
- explore the Gray Fossil Site Museum – an ancient karst feature containing some of the most significant Cenozoic fossil remains in eastern North America.
- enjoy some awesome eats for lunch at Wilderness Road State Park and dinner at Gray Fossil Site included with the trip.

Thursday and Friday we'll have more traditional NCKMS sessions, including a special session on WNS Thursday afternoon after the break. After the WNS session, authors will be present for a pre-banquet poster session social. We'll end the evening with Mike Ficco of the Cave Conservancy of the Virginia's telling us about the history, achievements, and challenges of sister organizations the Cave Conservancy of the Virginias and the Cave Conservancy Foundation.

For those of you traveling on to the TAG Fall Cave-in, drive safe and have fun. Hope to see everyone in two years at NCKMS 2021.

Your 2019 National Cave and Karst Management Symposium Planning Committee,

Wil & Zenah Orndorff, Katarina Kosič Ficco, Bob Hoke, Jerry Lewis, Steve Lindeman, Tom Malabad, and Janet Tinkham.



WEST VIRGINIA CAVE CONSERVANCY

Preserving Caves, and Access to Caves

WVCC.NET

2019 National Cave and Karst Management Symposium

7 – 11 October 2019

Bristol, Virginia, United States of America

Organized under the Auspices of the National Cave and Karst Management Symposium

National Cave and Karst Management Symposium Steering Committee:

Jim Kennedy: National Speleological Society, Committee Chair
Jim Goodbar: Bureau of Land Management
Scott House: Cave Research Foundation
Steve Taylor: Karst Waters Institute
Gordon Smith: National Cave Association
George Veni: National Cave and Karst Research Institute
Cory Holliday: The Nature Conservancy
Johanna Kovarik: U.S. Forest Service
Dave Foster: American Cave Conservation Association
Tommy Inebnit: U.S. Fish and Wildlife Service
Ben Miller: U.S. Geological Survey

National Cave and Karst Management Symposium 2019 Planning Committee:

Wil Orndorff (chair): Va Dept of Conservation and Recreation; VSS
Cory Holliday: The Nature Conservatory
Bob Hoke: Cave Research Foundation
Katarina Kosič Ficco: Va Dept of Conservation and Recreation
Jerry Lewis: Lewis and Associates Biological Consulting
Steve Lindeman: The Nature Conservancy
Tom Malabad: Va Dept of Conservation and Recreation
Zenah Orndorff: Va Dept of Conservation and Recreation volunteer; VSS
Janet Tinkham: Cave Conservancy of the Virginias

Welcome to Virginia, home of 4000+ documented caves with 570+ miles of surveyed passage. For more information on Virginia caves visit **virginiacaves.org**

We hope you'll enjoy your stay!

Virginia Speleological Survey

All presentation sessions will meet in the Grand Ballroom
All breaks, lunch, and the banquet will meet in the Presidential Ballroom
Posters will be available all day Tuesday, Wednesday, and Thursday
Silent auction will open Tuesday morning and close Thurs at 5:30pm

SATURDAY AND SUNDAY, OCT 5 + 6 2019	
8:00am—6:00pm	Wild Caving (meet in Hotel Lobby)
MONDAY, OCT 7 2019	
8:00am—7:00pm	Learning about *Lirceus* (with Jerry Lewis and Wil Orndorff)
8:00am—6:00pm	Wild Caving (meet in Hotel Lobby)
9:00am—4:00pm	CRF board meeting
5:00pm—10:00pm	Registration and check-in
7:00pm—10:00pm	Welcome reception
TUESDAY, OCT 8 2019	
7:00am—8:45am	Registration and Check-in
8:45am—9:00am	Opening Comments
9:00am—10:15am	Holsinger's Legacy
10:15am—10:30am	Morning Break
10:30am—12:00pm	Cave Conservation I
12:00pm—1:15pm	LUNCH / NCKMS Steering Committee Meeting
1:15pm—3:00pm	Cave Conservation II
3:00pm—3:10pm	Afternoon Break
3:10pm—5:00pm	Cave and Karst Management
5:30pm— midnight	Howdy Party: Bristol Station Brews and Taproom
WEDNESDAY OCT 9 2019	
8:00am – 10:00pm	Field Trip: Karst Destination of the Mountain Empire Dinner Social at Gray Fossil Site
THURSDAY OCT 10 2019	
8:45am– 10:20am	Biology I
10:20am—10:40am	Morning Break
10:40am—12:00pm	Biology II
12:00pm-1:00pm	LUNCH
1:00pm—3:15pm	Gates and Geeks
3:15pm—3:30pm	Afternoon Break
3:30pm—5:00pm	WNS SESSION
5:30pm—7:00pm	Pre-banquet poster social (authors preset 5:30—6:45)
7:00pm— midnight	BANQUET and Keynote Address

FRIDAY OCT 11 2019	
9:00am—9:40am	Hydrology
9:40am—10:20am	We're With The Government and We're Here to Help
10:20am—10:40am	Morning Break
10:40am—12:00pm	We're (mostly) With The Government and We're Here to Help

POSTERS: on display all day Tues through Thurs.

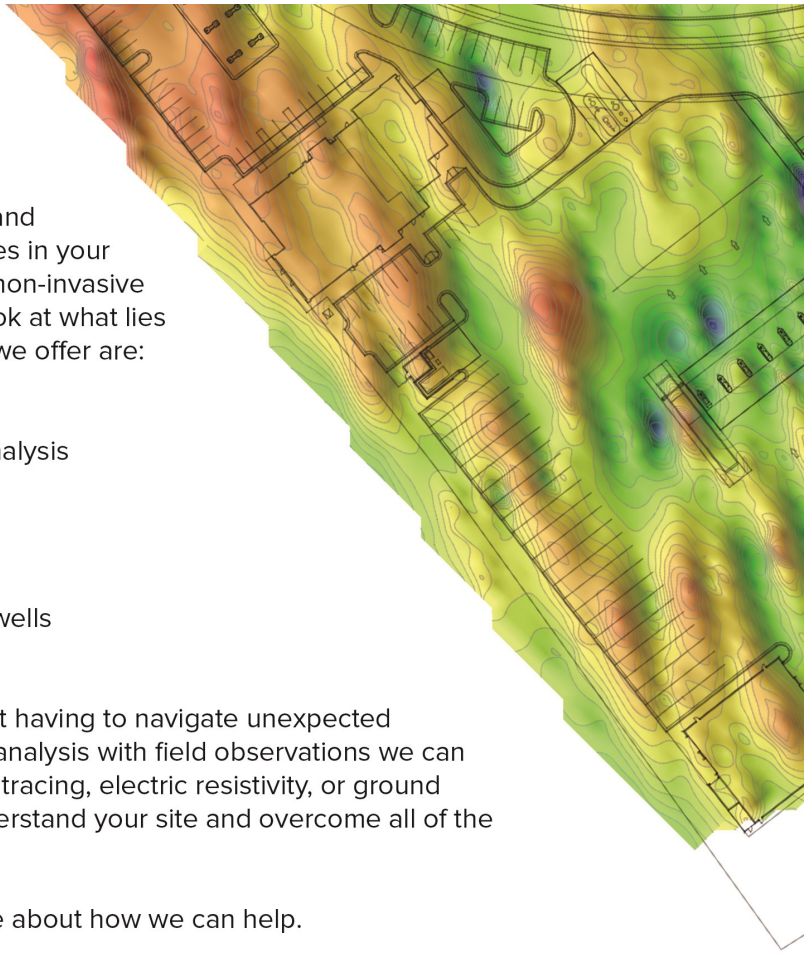
Pre-banquet poster session Thurs 5:30—7:00pm (authors present 5:30—6:45)

Steve Ahn	Nitrate Loading in Karst Streams: An NSF-RET Tale of Collaboration and Student Involvement
Greg Horne	Miniaturization of Temperature Data Logger and Enhanced Recovery Technique of Bats in Hibernacula
Scott House	Butler Hollow Cave Project
Scott House	The Missouri Cave Database
Scott House	Cave and Bat Management on Ozark National Scenic Riverways
Pat Kambesis	A Geochemical Comparison of Two Telogenetic Karst Springs During Reverse Flow, Mammoth Cave, Kentucky
Erin Lynch	Inventorying Broken Speleothems to Quantify Visitor Impacts in Carlsbad Cavern, New Mexico.
Wil Orndorff	Using the Bat Call Data Recorder as a Smart Alternative for Monitoring Bat Activity Levels: Examples from Gray Bat (Myotis grisescens) Summer Roosts in Virginia
Diana Schmidt	The Presence of Pharmaceuticals and Personal Care Products in Appalachian Karst Waters
Charles Stephen	Addressing the Taxonomic Impediment: Updating the Biodiversity of Subterranean Pseudoscorpions in Virginia
Sarah Truebe	High-Resolution Measurements of Cave Air pCO2 in the Context of 30 Years of Cave Air Carbon Dioxide Data

The SILENT AUCTION was supported by the following merchandise sponsors:
*** indicates businesses located in (or near) downtown Bristol, check 'em out!**

*Benjamin Walls photography
*Fabric etc…
*Misty Mountain
*Mountain Empire Comics
*Mountain Sports Ltd
*The Answer
Inner Mountain Outfitters
Lost World Caverns
Sinking Creek Pottery

Surprises should not be a fact of life.

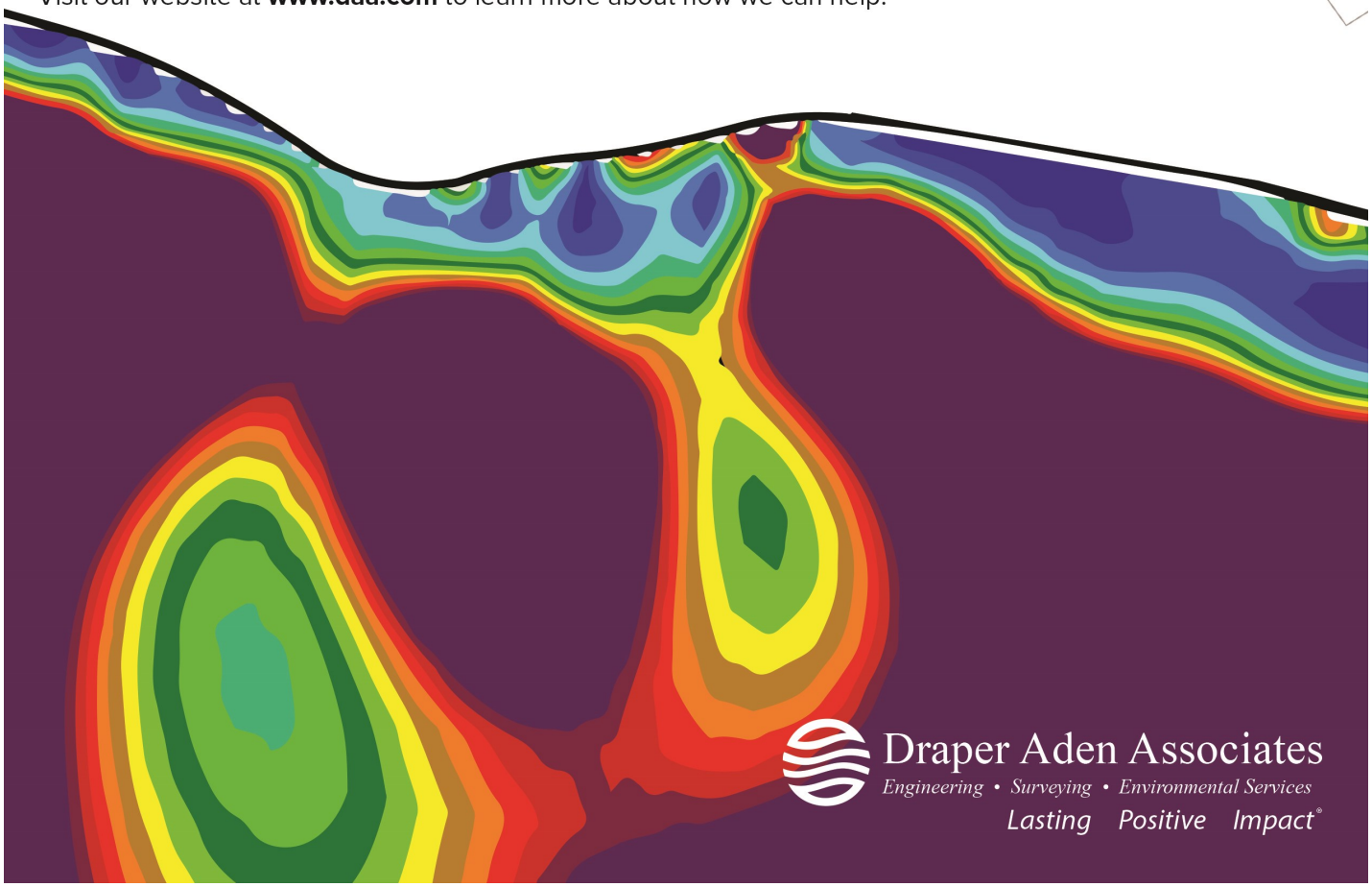


At Draper Aden Associates, our Environmental and Geophysics Teams can help you reduce surprises in your engineering and construction project. We offer non-invasive and non-destructive means to help you get a look at what lies beneath or in the vicinity. Some of the services we offer are:

- Karst terrain assessment
  - Dye tracer and hydrologic studies
  - Geospatial modeling and terrain analysis
  - Sinkhole evaluation and mitigation
- Geophysical imaging
  - Bedrock mapping
  - Geohazard characterization
  - Fracture zone mapping for water wells
  - Subsurface feature detection

Design and construction is hard enough, without having to navigate unexpected challenges. By combining remote sensing data analysis with field observations we can then select appropriate techniques such as dye tracing, electric resistivity, or ground penetrating radar. Now is the time to better understand your site and overcome all of the unique challenges by being proactive.

Visit our website at **www.daa.com** to learn more about how we can help.



TUESDAY PRESENTATIONS

8:45	W. Orndorff J. Lewis	Opening comments
HOLSINGER'S CONSERVATION LEGACY (moderator Bill Balfour)		
9:00	D. Culver	J.R. Holsinger—Premier Cave Conservationist
9:30	T. Brown	Appalachian Cave Conservancy (ACC)
9:45	M. Weberg	The Virginia Cave Board: A Unique Resource for Karst Management in Virginia
10:00	T. Malabad	Conservation Assessment of Natural Heritage Cave Resources in Virginia: Phase 1, New River Karst Region
10:15	**MORNING BREAK**	
CAVE CONSERVATION I (moderator Tom Malabad)		
10:30	R. Simmons	The Northeastern Cave Conservancy, Inc. an Introduction
10:45	M. Burger	Risk Management Strategies for Cave Conservancies
11:00	T. Engel	Use of Clarksville Cave Preserve
11:15	J. Jahn	The Mid-Atlantic Karst Conservancy
11:30	B. Balfour	The West Virginia Cave Cave Conservancy: A Brief History
11:45	B. Alderson	Implementing and Enduring Public-Private Partnership: CRF and the Cumberland Gap National Historic Park
12:00	**LUNCH / NCKMS Steering Committee Meeting**	
CAVE CONSERVATION II (moderator Jerry Lewis)		
1:15	K. Bailey	The Kentucky Karst Conservancy: How a Cave Got Protected Over Dinner
1:30	C. Walkey	The Southeastern Cave Conservancy in 2019
1:45	J. Simek	Cherokee Syllabary in Howards Waterfall Cave, Georgia: Conservation and Interpretation of Cultural Resources in a Southeast Cave Conservancy Preserve
2:00	S. Lewis	Cavers Conserving Karst: The Indiana Karst Conservancy
2:15	K. Kosič Ficco	A Unified Interdisciplinary Approach for the Protection of Karst Aquifers
2:30	J. Lyles	Improvements for Access to Edgewood Cavern in Central New Mexico
2:45	D. Vaughn	Karst in Perry County
3:10	**AFTERNOON BREAK**	
CAVE AND KARST MANAGEMENT (moderator Meredith Weberg)		
3:30	T. Woelk	New River Cave Preserve: A Study of the Spelunker and his Tools
3:45	M. Junod	Hydrologic Connections Between Precipitation, Dripwater, and Stream Discharge: in James Cave, Virginia
4:00	J. Despain	Cave Management Law, Policy and Implementation in the Philippines
4:15	T. Griffin	How Important are Grottoes to Landowner Relations?
4:30	Poster "lightning talks"	
HOWDY PARTY at Bristol Station Brews and Taproom		
5:30-12:00	Shuttle will run continuously between Holiday Inn and Bristol Station: First shuttle leaves Holiday Inn at 5:30 and will return approximately every 30 mintues. Last shuttle leaves Bristol station at midnight.	

2019 NCKMS Wednesday Field Trip

Karst Destinations of the Mountain Empire: 8:00am—10:00pm

The field trip will feature visits to three of the more spectacular karst features of the Mountain Empire developed for public access: Gap Cave at Cumberland Gap National Historical Park, Natural Tunnel State Park in Virginia, and the Gray Fossil Site and Hands On Museum of East Tennessee State University.

As you drive across the ridges and the valleys of the Mountain Empire, you'll pass exposures of Paleozoic limestone and dolomite spanning most of the Paleozoic from Cambrian to Mississippian time. As the southern Appalachians continue to uplift, streams of the Upper Tennessee River system – the Clinch, Powell, and Holston rivers and their tributaries – cut down through these rocks, exposing and continuing to form truly world class cave and karst systems. Due to the folding and faulting in the Valley and Ridge province, the karst generally occurs on mountain sides and along valley floors in belts and coves produced by dipping and folded strata that host more than a thousand caves in southwestern Virginia and northeastern Tennessee. Caves several miles in length and hundreds of feet in depth are common, and the area includes the Omega Cave system, a nearly 30 mile long system that is the deepest cave east of the Mississippi at 1263 feet. Large caves are developed in rock of all ages, and karst of each unit has its own distinctive style. This diversity is mirrored in that of the invertebrate cave fauna, among the richest in North America. Water from these cave and karst systems supports one of the most biodiverse freshwater ecosystems in the world.

Gap Cave - Cumberland Gap National Historical Park

With over seventeen mile of cave mapped to date, and more to go, Gap Cave is one of the hidden karst jewels of the National Park System. We will visit this incredible cave, formed in the Mississippian-aged Greenbrier (Newman) limestone along Cumberland Mountain, and which was visited by and provided water to early European settlers as they made their way through Cumberland Gap into what would become Kentucky. Developed in the same band of rock as Omega and several other large, deep caves, Gap Cave has been a challenge to explore due to the arrival of White Nose Syndrome during the middle of the survey project. As we'll learn at lunch and from talks at the meeting, the Cave Research Foundation and the management at Cumberland Gap National Historic Park continue to work together to keep the project going while at the same time adopting measures to protect bat populations in the cave, which were hit by WNS in 2013. Be aware that this cave, like all others in the area, should be considered WNS positive. Clothing and equipment taken into Gap Cave should not be taken into caves in areas where WNS is not known to occur.

Wilderness Road State Park

Our lunch stop will be at Wilderness Road State Park, which celebrates both the western migration of European settlers along Daniel Boone's trail and the Native American cultures of the region. In addition to the historical exhibits and interpretive programs, the Park manages an archaeologically significant cave on the property that is not open to the public due to its significance. No matter where you go in the Mountain Empire, caves are always just around the corner. We won't have time to visit the Park's exhibits on this trip, but we encourage you all to return when you can and learn more about this period in American history. You'll notice bison in the fields as we enter the park, a reminder of the pre-Columbian fauna that roamed the Powell Valley.

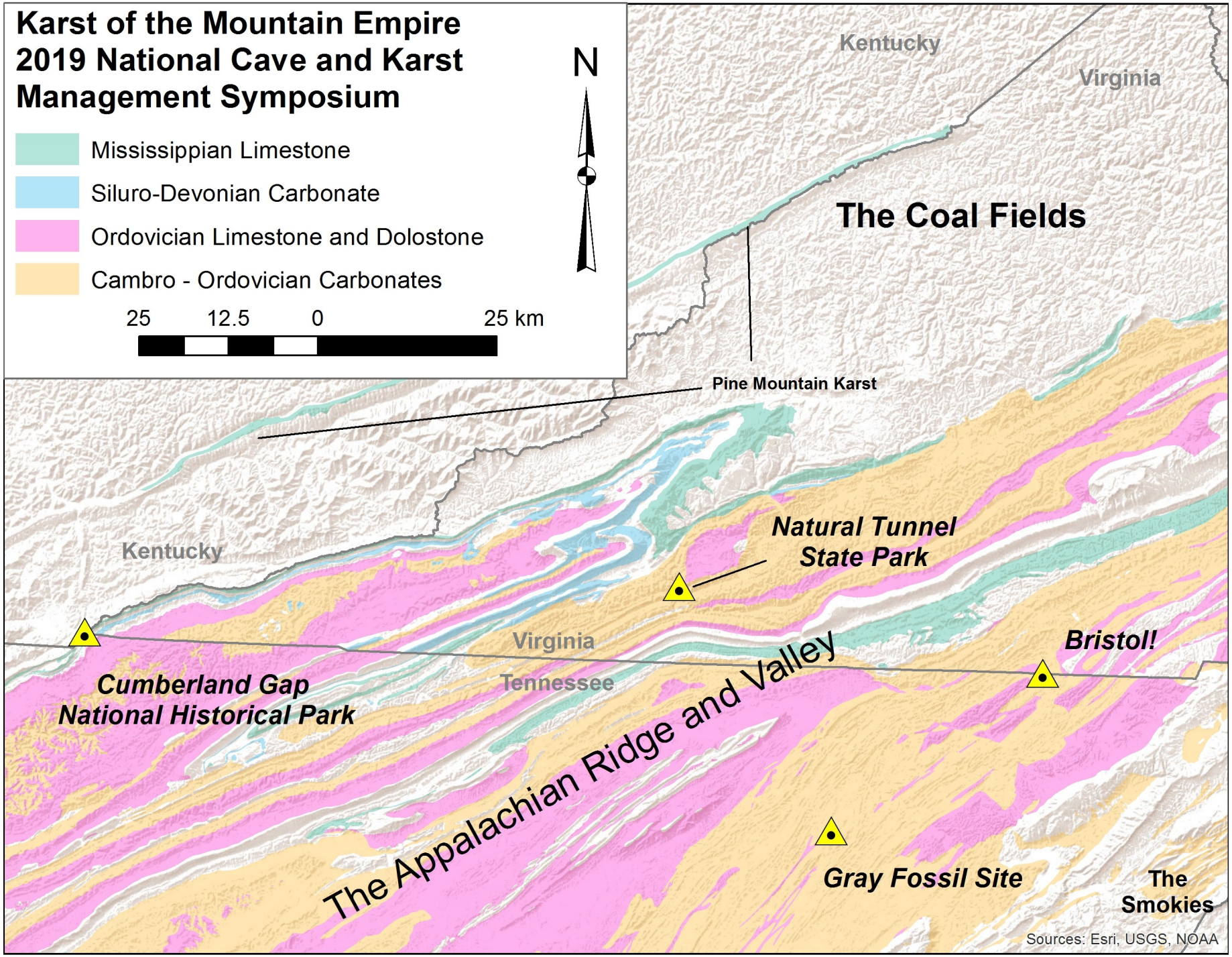
Natural Tunnel State Park

An extreme example of human modification of caves, the Natural Tunnel is a cave converted by man to accommodate the Norfolk Southern Railway on its journey from the coal fields of the Appalachian Plateau to markets along the eastern seaboard. You can ride the chair lift or hike to the tunnel's downstream entrance and back, where geologist and author Tony Scales will discuss the geological origins and history of the Natural Tunnel, which is developed in the Ordovician-aged Chepultepec Formation. We will also hear from park interpreters about how they integrate wild caves on the park into their education and outreach programs.

Gray Fossil Site

The Gray Fossil Site is a fantastic example of a paleo-karst fossil deposit and an even better example of innovative and forward thinking on the part of state government. Dr. Blaine Schubert, the Center's director, will tell us the story of how former Tennessee Governor Don Sundquist led the charge to turn an unusual fossil deposit discovered during excavation for a state highway project into a leading center for the study of Cenozoic fossils in eastern North America and an unparalleled educational resource for Eastern Tennessee State University and citizens of the region. We'll get a chance to tour the dig, roam the exhibit halls, and grab some dinner before enjoying Blaine's presentation—Chasing Short-faced Bears Through Caves, Karst, and Time: from the Gray Fossil Site to the Yucatan .

Note that there are other karst destinations in the Mountain Empire, including the privately run Bristol Caverns and Appalachian Caverns in nearby Sullivan County, TN. We encourage you to check out these attractions if you have time.


Karst of the Mountain Empire
2019 National Cave and Karst Management Symposium
N
Mississippian Limestone
Siluro-Devonian Carbonate
Ordovician Limestone and Dolostone
Cambro - Ordovician Carbonates
25 12.5 0 25 km
Kentucky
Virginia
The Coal Fields
Pine Mountain Karst
Kentucky
Natural Tunnel State Park
Virginia
Tennessee
Bristol!
Cumberland Gap National Historical Park
The Appalachian Ridge and Valley
Gray Fossil Site
The Smokies
Sources: Esri, USGS, NOAA

ESI

Environmental Solutions & Innovations, Inc.

Real Science, Real Solutions

Five Decades Underground

Conserving & Protecting Cave & Karst Dependent Species

OUR CULTURE

ESI's association with cave and karst conservation dates back to the mid-1970s when founder and Principal Scientist, Dr. Virgil Brack, Jr. was a member of a team conducting research into use of MO Caves. After completing an MS on the physiology of hibernation, he left for IN and completed a Ph. D. focused on the Indiana bat. During this work, he began regular censuses of hibernating bats in caves of IN, which have remained in the focus of Dr. Brack's career. Since founding ESI in 2000, Dr. Brack continued to build a team of scientists whose expertise includes both bats and karst systems. Our staff have worked underground in 17 states (See Map), and although this includes such iconic locations as Wyandotte Cave, IN, Hell Hole Cave, WV; Fern Cave, AL; Hubbard's and Bellamy Caves, TN, the Newberry-Bane Cave complex of Skydusky Hollow, VA; the Gypsum Hills Region of KS, and the Ozark Plateau of MO, AR, and OK, it also includes Preble, Blackball, and Sodalis Nature Preserve hibernacula in mines in OH, IL, and MO. And, we have completed work at cave entrances in several additional states.

OUR COMMITMENT

ESI's staff includes leaders in many disciplines, dedicated to cultivating the next generation of karst biologists. Some of our leaders and their specialties include:

- **Patrick Moore** – Bat hibernacula/maternity surveys and interior highlands karst
- **Tom Jones** – Cave fish and water quality in underground systems
- **Casey Swecker** – Cave crayfish and other aquatic inverts
- **Dale Sparks and Lynn Robbi ns** – Links between caves, karst, mining activities, and surface biology of bats
- **Ken Landgraf** – Caves, karst, and hydrology on public lands
- **Darwin Brack** – Bat hibernacula/maternity surveys and assessments for White Nose Syndrome

We support our staff with the tools they need, from the sublime technical and electronic gear for measuring and monitoring the cave environment and its inhabitants, to the ordinary including vehicles, vertical gear, and WNS-protection. Although we work commercially, we volunteer frequently and have often contributed far beyond any compensation for many important projects such as intra-cave censuses and helping to document the devastating spread of WNS.

OUR KNOWLEDGE, EXPERIENCE, AND TALENTS

ESI staff have a broad geographic, taxonomic, and regulatory base. Our services range from answering simple questions on presence or absence of rare species to developing mathematical models that predict impacts from decades of activities to multiple species in a region. With these data, we help clients and agencies understand options, ranging from making a go/no-go decision to implementing long-term management plans.

BENEFITS TO THE RESOURCE

At ESI, we zealously advocate for both clients and resources. We provide clients and regulatory agencies information that is factual and informed by the best scientifically or commercially available data, upon which regulatory decisions are made. To achieve this goal, we often collaborate and publish with academic researchers—we not only know the best available science, we help produce it. Our contributions to peer-reviewed, scientific literature is found at our website, http://www.Envsi.com. Often, these partnerships provide innovative solutions with real benefits to both the resource and the project proponent, enhancing our credibility with clients, regulators, and the conservation community – the three largest stakeholders in the environmental community. Cave-dependent species benefit through a variety of partnerships.

- ➥State resource agencies
- ➥Departments of Transportation and FHWA
- ➥Federal agencies (USFWS, USFS, NPS, DOD, TVA)
- ➥NGOs (conservation and caving organizations)
- ➥Universities
- ➥Private Industry (energy, transportation, forestry, and other consulting companies)

ESI is steadfast in our goal to improve natural resource management using science-based methods implemented by top consultants and researchers. Karst resources increasingly face constraints and challenges; ESI is addressing these issues to benefit clients and the resources.

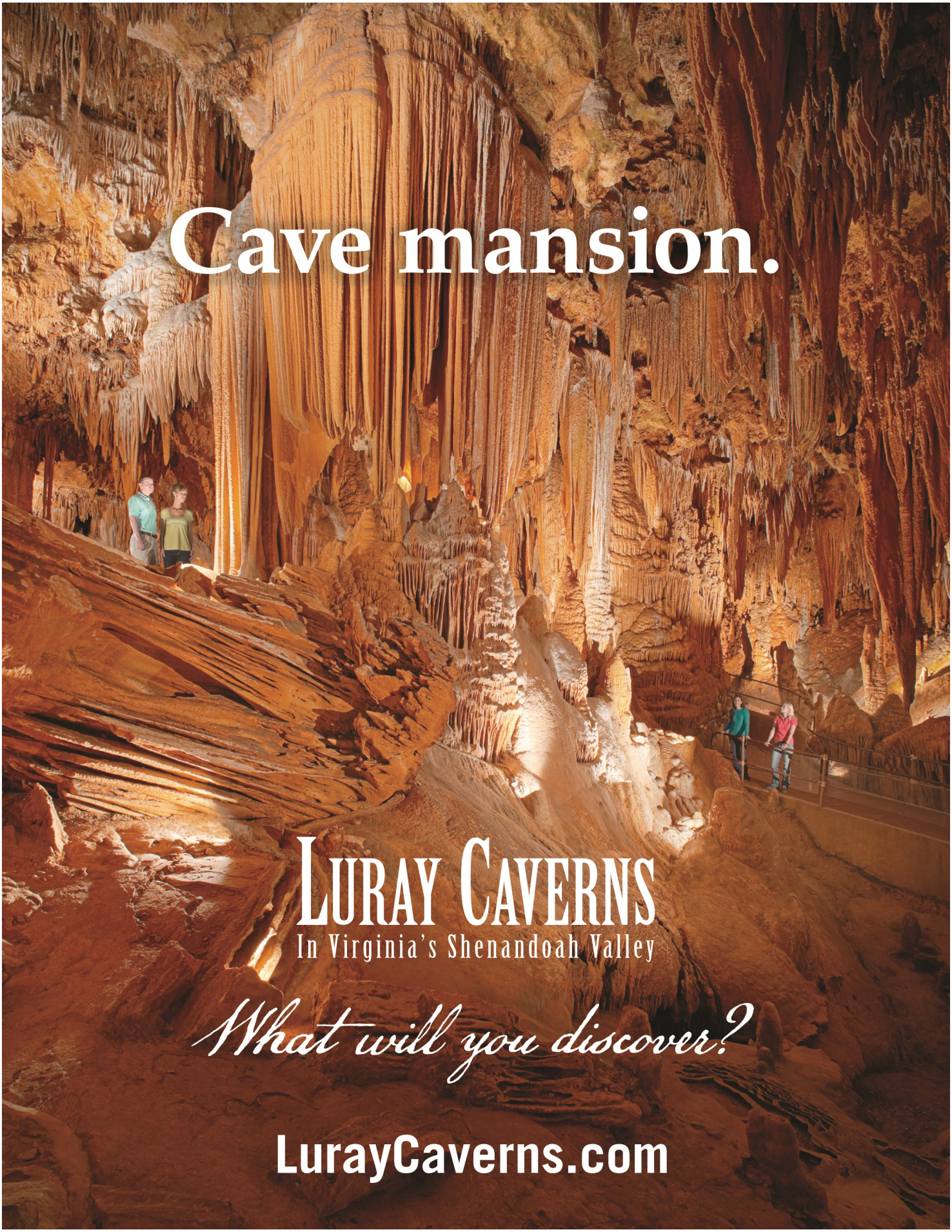
For more information call:
513-451-1777

Cincinnati. OH • Ravenna, OH • Indianapolis, IN • Orlando, FL
Springfield, MO • Pittsburgh, PA • Teays Valley, WV

ENVSI.COM

THURSDAY PRESENTATIONS

8:45	W. Orndorff	Opening Comments
BIOLOGY I (moderator Mike Slay)		
8:50	J. Lewis	Endangered Species Management in an Era of Ever-Increasing Biodiversity: A Case Study of the Molecular Phylogenetics of *Lirceus hargeri*
9:20	B. Miller	Recharge Area Delineation for Manitou Cave to Aid in Threat Assessments for Sensitive Stygobionts
9:40	T. Inebnit	Comprehensive Biodiversity Inventory of the Fern Cave System at Fern Cave National Wildlife Refuge, Jackson County, Alabama
10:00	M. Niemiller	Using Environmental DNA for the Detection and Monitoring of Groundwater Life: A Case Study on Cave-Dwelling Decapods in Northern Alabama
10:20	**MORNING BREAK**	
BIOLOGY II (moderator Matt Niemiller)		
10:40	G. Baker	Preliminary Analysis of Biomonitoring Data and Supplementary Information over 13 years in Lehman Caves, Great Basin National Park, Nevada
11:00	R. Adams	Tree Roots in Caves of Quintana Roo, Mexico: Ecological Insights and Conservation Implications
11:20	A. Tsalickis	Using Bat Guano from Cave Springs Cave in Northern Alabama to Reconstruct Moisture Patterns Throughout the Holocene
11:40	J. Lewis	Sinkholes: Biodiversity Hotspots of Epigean Terrestrial Karst Ecosystems
12:00	**LUNCH**	
GATES and GEEKS (moderator Andrea Futrell)		
1:00	S. House	The Butler Hollow Project in Missouri
1:20	C. Holliday	Evaluating Cave Gate Compromises and Reconsidering Alternatives
1:40	P. Schuchardt	Create Quick 3D Working Maps with CaveWhere
2:00	B. LaSala	Creating a High-Resolution Simulation of the Timpanogos Cave System Using a Terabyte Scale LiDAR Dataset
2:20	H. Richardson	The Importance of a Karst Club in High School
2:35	J. Vaughan	Optimizing Karst Feature Characterization - Integrating Non-Invasive Geophysical Methods with Invasive Geotechnical Sampling
2:55	D. Doctor	Lidar-Derived Elevation Models and Imagery as Tools for Karst Feature Mapping and management
3:15	**AFTERNOON BREAK**	
WNS SESSION (moderator Cory Holliday)		
3:30	R. Simmons	Initial Report, Outside Influences on Caves Project, New York
3:45	J. Reichard	WNS Impacts Analsyis
4:05	S. Hopkins	WNS Survival and Persistence by Indiana bats
4:25	P. Pattavina	Significant Control Research Updates
4:45	WNS Open Forum Discussion	
POSTERS and BANQUET		
5:30 7:00 - ???	Pre-banquet poster social—authors will be available with their poster BANQUET and Keynote Address by Mike Ficco: Filling the Voids - Cave Conservancy of the Virginias and the Cave Conservancy Foundation	


Cave mansion.
LURAY CAVERNS
In Virginia's Shenandoah Valley
What will you discover?
LurayCaverns.com

FRIDAY PRESENTATIONS

	HYDROLOGY (moderator Pat Kambesis)	
9:00	R. Denton	The Use of Dye Tracing to Develop a Mitigation and Response Plan for Two Karst-Based Public Water Supplies in Augusta County, Virginia
9:20	G Horne	Use of Time Lapse Photography to Monitor Seasonal Ice Formation in Castleguard Cave, Alberta, Canada
WE'RE WITH THE GOVERNMENT AND WE'RE HERE TO HELP (moderator K. Kosič Ficco)		
9:40	S. Truebe	How Many Rangers Does it Take to Change a Lightbulb? The saga of Upgrading an Aging Cave Lighting System
10:00	R. Horrocks	Using Show Cave Lights as a Cave Management and Interpretive Tool
10:20	**MORNING BREAK**	
WE'RE (mostly) WITH THE GOVERNMENT AND WE'RE HERE TO HELP (moderator K. Kosic Ficco)		
10:40	P. Seiser	Lava Beds National Monument: Test Site for Mars missions (On Becoming the Prototype Lava Beds IntraGalactic Monument for Mars)
11:00	A. Armstrong	Best Practices for Collection of Paleoclimate Records from Active Speleothems
11:20	M. Futrell	Cave Research When all the Caves are on Private Land
11:40	W. Orndorff	Virginia Update on Linear Energy Projects Crossing the Appalachian Karst: Atlantic Coast and Mountain Valley Natural Gas Transmission Pipelines
12:00	**CLOSING COMMENTS….GO HOME….**	

Cave Conservancy Foundation

The ***Cave Conservancy Foundation (CCF)*** promotes the conservation, management, and understanding of caves and karst resources by supporting research, education, and stewardship initiatives beyond the Virginias.

CCF sponsors a wide range of speleo-science investigations to advance our knowledge of biogeography, hydrogeology, paleo-climatology, sediment transport, and anthropology.

CCF also funds cave protection and outreach projects that address land use impacts, water quality, sinkhole cleanups, vandalism, cultural history, climate change, and mapping.

CCF is proud to increase community involvement and appreciation for karst resources by sponsoring teaching module development, field trips, workshops, training, and meetings such as the National Cave and Karst Management Symposium.

Our flagship program offers three academic Fellowships in Karst Studies with funding at the Doctorate, Masters, and Undergraduate levels. Further information about grants and scholarships is available at www.caveconservancyfoundation.org.

Tree Roots in Caves of Quintana Roo, Mexico:
Ecological Insights and Conservation Implications

Adams, Rachel E.*[1] (rachelroenfeldt@tamu.edu); Iliffe, Thomas M.[2]; West, Jason B.[1]

[1]Department of Ecosystem Science and Management, Texas A&M University, College Station, TX 77843; [2]Department of Marine Biology, Texas A&M University at Galveston, Galveston, TX 77553

While ecological connections between the surface and subterranean realms are inherent, the two are sometimes set apart and not studied collectively. In the Yucatán Peninsula of Mexico, tree roots link these two worlds, making them impossible to separate. Here, roots commonly grow into caves, often contacting groundwater. Yet, little is known about which tree species provide these roots or how the tropical forests and caves are associated ecologically. To investigate this, we established paired above and below ground plots at five private caves in Quintana Roo. We evaluated relationships between forest composition, water access, and root biodiversity through biomass surveys, stable isotopes, and genetic approaches. Results show that nearly half of the tree species present above ground were found in caves. Root biodiversity in caves was dominated by the families Moraceae and Fabaceae, and species from these families were the dominant species above ground as well. Stable isotopes from stem water showed increased cave water use with increasing tree size, which corresponded to a decrease in water stress. Local bedrock characteristics contributed to observed variability in water access within the karst landscape. This work demonstrates that multiple tree species have potential to access water in caves, but access seems limited by the bedrock itself. During field work, interest in the tree roots among landowners, tourists, and tour guides became apparent. We believe that understanding the surface and subterranean holistically can guide protection and management of the resources within tropical forests and caves, especially in the face of expanding urbanization in Quintana Roo.

Nitrate Loading in Karst Streams:
An NSF-RET Tale of Collaboration and Student Involvement

Ahn, Steve*[1] (sahn@wcs.k12.va.us); Napier, Aaron[1]

[1]Holston High School, 21308 Monroe Rd, Damascus, VA 24236

In 2018 and 2019, teachers from a local high school participated in a National Science Foundation (NSF) -funded Research Experience for Teachers hosted at Virginia Tech. Nitrate loading of karst streams was studied by analyzing nitrates in 7 cave streams all located in Southwest Virginia and Northeast Tennessee. In order to determine if land use affects nitrate levels in karst streams, Geographic Information System (GIS) software was utilized to determine the percentage of pastured, forested, and urban land that lies within a 1km radius of sample locations. Nitrate levels in karst streams were found to have a strong positive correlation to percent hay/ pasture and a strong negative correlation to percent forested land use. In addition to the research project, an educational unit was developed to expose students to karst issues and to get them actively involved in experiential learning, cave science, and caving. The presentation will highlight the array of benefits of a collaboration between numerous entities from the federal level all the way to local high school students.

Implementing an Enduring Public-private Partnership:
The Cave Research Foundation and Cumberland Gap National Historical Park

Alderson, Bob[*1](alderson64@msn.com); Beeler, Jenny[2]; Brown, Terri[3]

[1]Cave Research Foundation, 4043 Rutrough Rd SE, Roanoke, VA 24014; [2]Cumberland Gap National Historical Park, 91 Bartlett Park Road, Middlesboro, KY 40965 [3]Department of Natural Sciences, The University of Virginia's College at Wise, 1 College Avenue, Wise, VA 24293

The partnership between the Cave Research Foundation (CRF) and the Cumberland Gap National Historical Park (CUGA) began in 2003. A Memorandum of Understanding (MOU) between CRF and CUGA provided guidelines for the Gap Cave Cartography Research Project and addressed National Park Service concerns about data sharing, security, and procedures. CUGA harbors an array of caves and karst resources and is the source of essential habitat and public drinking water supplies. The partnership between CUGA and CRF has resulted in the documentation of over seventeen miles of passage in Gap Cave alone, and the discovery of multiple virgin sections. These new discoveries, in turn, led to the development of specific conservation protocols intended to protect pristine areas. Prior to White Nose Syndrome (WNS), CUGA enforced policies designed to protect endangered species (such as Indiana bats) that included closing specified areas and caves during hibernation and access-control with bat-friendly cave gates. Beyond the developed tourist route, caver access was restricted to research, including survey, historical-cultural documentation, and hydrological and biological inventory. WNS arrived in the Virginias in 2009, and within a few years, populations of several bat species were decimated. Due to the potential for fungal spore transport on caving gear, further public-private cooperation between natural resource managers and the caving community led to development of decontamination procedures and varying caving restrictions. The US Forest Service closed all caves on its lands during this time, and other Parks required dedicated caving gear. CUGA, however, wrote a successful challenge cost-share proposal accounting for CRF's contributions that funded purchase of CUGA-dedicated caving gear plus equipment for washing and decontamination, and allowed CRF's research to continue. WNS was not documented in CUGA until 2013, despite the protocols, which may have delayed its arrival. As CRF expanded its research focus to include the preservation and documentation of Civil War signatures and investigation of seasonal hydrobiochemical signatures, CRF encountered some Wilderness designation restrictions that have been resolved through the partner interaction and permitting process. Any actions in Wilderness areas must go through a "minimum requirements analysis" step that adds extra time to a given project, but ultimately ensures that all options have been discussed and that the least disruptive practices will be employed. Due to our mutual trust factor and positive track record, CUGA (in consultation with the US Fish and Wildlife Service) has recently been able to advance from wholesale cave closure to protection of hibernacula during the winter months, to the point of allowing a limited number of winter scientific cave trips, as long as certain areas can be avoided. CRF's ongoing relationship with CUGA has been long and rewarding, and while there will always be challenges to deal with, we have seen caver feedback and communications incorporated into CUGA's management strategies in significant ways. What could possibly provide more validation than that?

Best Practices for Collection of Paleoclimate Records from Active Speleothems

Armstrong, Andy*[1](andy_armstrong@nps.gov); Quirk, Brendon[2]

[1]Timpanogos Cave National Monument, Division of Science and Resource Management, RR3 Box200 American Fork, UT 84003; [2]University of Utah, Geology & Geophysics, 115 S 1460 E, Room 383, Salt Lake City, UT 84112

In August 2016, a research team from the University of Utah and the U.S. National Park Service collected core samples from three speleothems at Timpanogos Cave National Monument in Utah. The cores were retrieved as part of a larger scientific project looking to understand paleoclimate during the Late Pleistocene in the Northern Great Basin. Stalagmites have recently emerged as key continuous, semi-quantitative descriptors of paleohydrology and climate. However, stalagmites are also some of the most important and visible geologic resources in a cave. This is especially true in publicly accessible caves, like Timpanogos Cave, where stalagmites are both geologic features that are preserved and protected for their own sake and also serve as valuable resources for visitor enjoyment. Traditional sampling techniques, which can go as far as the sawing and removal of entire stalagmites, are not attractive options for cave managers who must balance scientific discovery with preservation. The collection of core samples down the growth axis of a stalagmite mitigates resource impact while ideally still providing the most important material for scientific inquiry. In addition to already yielding data about the effects of Lake Bonneville on local paleoclimate, cores from the Timpanogos cave will be preserved for future research. The core sites were restored using new best practice techniques in order to rehabilitate previous aesthetics and microhydrology.

The Kentucky Karst Conservancy: How a Cave Got Protected Over Dinner

Bailey, Kenneth (kbailey59@windstream.net)

Kentucky Karst Conservancy, 4408 Zoneton Road, Shepherdsville, KY 40165

Big Bat Cave is located in Breckinridge County, Kentucky. The mapped length is almost fourteen miles. The passages lie in the Paoli Limestone beneath the Sample Sandstone cap rock. Big Bat Cave's natural entrance lies at the corner of three properties with different owners. Exploration of the cave began in the early sixties by geology students from the University of Louisville, but documentation of these efforts was lost in the university archives. The second wave of exploration began in the mid-sixties. Unfortunately, most of the notes were destroyed in a flood but the stories and journals of these explorers survived. Many of the stories were told to me over dinner by JPat (James Patrick) Stevens, who helped discover the Mushroom Entrance, a second entrance to Big Bat Cave, which he subsequently purchased. Dinners were a great time to hear JPat tell stories and talk about the cave, and we often discussed how the Mushroom Entrance should be protected in the future. JPat and others made pioneering cave discoveries in Breckinridge County, and he and I discussed the transition from the time of exploration to the time of conservation for Big Bat Cave. That was the beginning of the Kentucky Karst Conservancy (KKC), which was established as a result of these conversations over dinner. The KKC owes a debt to Adam and Sariena Sampson and Delores (Lore) Berglund who believed in the conservation of Big Bat Cave and made it happen. Thank you James Patrick Stephens (NSS# 8320RE,FE) for your vision and generosity to caving.

Preliminary Analysis of Biomonitoring Data and Supplementary Information Over 13 years in Lehman Caves, Great Basin National Park, Nevada

Baker, Gretchen Marie*[1] (Gretchen_Baker@nps.gov); Horner, Margaret[1]; Roberts, Ben[1]; Long, Julie[1]

[1]Great Basin National Park, 100 Great Basin National Park, Baker, NV 89311

For the past thirteen years, fourteen paired stations in Lehman Caves have been visited to quantify cave invertebrate diversity and abundance. Supplementary data on cave microclimate, bait predation, and water presence have also been recorded. Over this time period, we have made over 50 trips into the cave and observed over 3,550 individual animals. By field identifiable groups, the most predominant invertebrates present were, in order, grey springtails (n=1821), white springtails (n=1040), millipedes (n=121), and pseudoscorpions (n=94). A marked decrease in the total number of individual invertebrates observed was shown from year 1 (n=702) to year 13 (n=94), although the downward trend has slowed, perhaps due to a change in baiting practices. Microclimate data has encompassed several variables, with soil temperature appearing to be the most robust. The peanut butter bait was found missing at some stations, thought to be due to rodent predation. Water presence has been found to be perennial at some cave locations, but ephemeral at others, tied into the rate of snowmelt and overall precipitation. This is one of the longest-running biomonitoring efforts in a show cave.

The West Virginia Cave Cave Conservancy: A Brief History

Balfour, Bill*[1] (bal4karst@hotmail.com); Bassett, Carroll[1]; Lindsay, Cliff[1]

[1]West Virginia Cave Conservancy, PO Box 243, Frankford WV 24938

The West Virginia Cave Conservancy (WVCC), a 501 c-3 non-profit organization, was founded in 1997. Its mission is to acquire and protect West Virginia caves and provide recreational opportunities where appropriate. Initially, the thought was to work primarily in the Greenbrier Valley, but the directors soon recognized the need to encompass the entire state and surrounding areas if we wanted to garner broad support among eastern cavers. The WVCC is composed of nine directors elected by the membership for a term of nine years, with elections staggered so that three directors are elected every three years. The elected directors appoint the officers of the corporation. WVCC holds three meetings per year, all open to all members, and hosts a banquet each fall in appreciation of the membership's support. The WVCC has been able to acquire access/ ownership of three of the seven classic contact caves in the Greenbrier Valley giving cavers over 50 miles of cave to explore. Recent discoveries suggest that the largest cave system in the state may soon be realized with WVCC managing two of its entrances. The WVCC also owns the main entrance to another very popular 20 mile long system. In addition, the Conservancy owns two very popular recreational caves elsewhere in the state and two in Virginia, and has management agreements with two other properties in Greenbrier County. WVCC is currently pursuing acquisition of a cave in Tucker County.

Risk Management Strategies for Cave Conservancies

Berger, Mitchell (m.berger@necaveconservancy.org)

Northeastern Cave Conservancy, PO Box 254, Schoharie, NY

Cave conservancies strive to grow – we want to protect more caves and karst, we want more volunteers and larger membership bases, and we want more of the public and the caving community to experience the wonders of nature that we dedicate our efforts to protect and preserve. With this growth comes an ever-increasing risk of something going wrong, and the risks we face are numerous and diverse. They include visitors or volunteers getting hurt on (or under) our land, vandalism, land deals that lead to disputed boundaries, unfriendly neighbors who cause damage to our land and danger to our visitors, accusations of discriminatory practices or mismanagement of funds, theft, and many others. We will explore several of these risks and a variety of options for protecting against them, along with the pros and cons of each option. Topics discussed will include waivers, conservation easements, various types of insurance (general liability, directors and officers, property, etc.), Terrafirma, "sportsman's laws," etc. This presentation will show that risk management is not a one-size-fits-all affair, with the "right" mix of protections often depending on the size of your organization, available resources, and the jurisdictions in which you conserve caves and karst. A number of suggestions and resources will be offered to help devise a strategy that meets the needs of your cave conservancy, drawing heavily on the Northeastern Cave Conservancy's research and experiences over the last several years.

Appalachian Cave Conservancy (ACC)

Brown, Terri (tlb9fd@uvawise.edu)

Department of Natural Sciences, The University of Virginia's College at Wise, 1 College Avenue, Wise, VA 24293

The Appalachian Cave Conservancy (ACC), Inc. is a non-profit organization formed in 1978 as the Perkins Cave Conservation and Management Society by long-time caver and cave conservationist, John Wilson. Our mission has always been to apply best management practices to the protection of caves on privately-owned lands in the Appalachian region. The organization's original focus was on the management of Washington County, Virginia's Perkins Cave and its surrounding acreage. In 2004, the Conservancy adopted its current name and expanded its scope to include additional caves within the upper Tennessee River watershed of southwestern Virginia and northeastern Tennessee, a recognized hotspot of biodiversity. The ACC owns the Gilley Cave property in Lee County, VA, and currently manages nine caves in its service area through agreements with ACC members and friends of the conservancy. The ACC accepts donations of cave entrances and karst lands, and enters into voluntary agreements with landowners to develop and implement effective management strategies based on site-specific characteristics, threats, and land use conditions. One disadvantage of this approach is dealing with new and sometimes hostile landowners when cave properties are sold. Most ACC caves are open to visitation by responsible cavers, with a select few restricted to scientific or conservation-related visitation only. With the support of more than 60 members, ongoing ACC activities involve cave surveying, graffiti and trash removal, education and outreach, management plan development, gate building and repair, and fund-raising.

John R. Holsinger—Premier Cave Conservationist

Culver, David C. (dculver@american.edu)

Karst Waters Institute, P.O. Box 4142, Leesburg VA 20177

John Holsinger died on November 18, 2018, at the age of 84, after a remarkable and unparalleled career as a taxonomist of subterranean amphipods from all over the world. He was also a cave biodiversity specialist, a cataloger of the caves of Virginia, an all-around speleologist, and cave conservationist. It is this last role that is the topic of this presentation. John was introduced to caving in 1954 through the Virginia Tech cave club, where he was an undergraduate student majoring in biology. In the late 1950's and early 1960's, together with John Cooper, he initiated a biological survey of Virginia caves supported by the National Speleological Society (NSS). This was one of the very first such undertakings anywhere in the world, and was important because it departed from the usual rather narrow taxonomic focus of cave biologists, and was to prove to be of great importance in cave conservation planning. After a stint in the army and as a teacher, he returned to graduate school at James Madison University and his 1963 M.S. thesis included a checklist of organisms found in Virginia caves. This was the first of three such checklists, the other two being monograph-length enumerations of the Virginia cave fauna, published in 1988 and 2013. This inventory work placed Virginia with more cave-limited species than any states except for Tennessee and Texas. Holsinger obtained his Ph.D. at the University of Kentucky in 1967 where he did a taxonomic revision of a large group of subterranean crustaceans, now placed in the genus *Stygobromus.* This taxonomic work continued for more than 40 years and resulted in the description of more than 100 species new to science, 40 of them from Virginia alone. Of course, John was not limited to studying the biology of caves. In 1975 he published *Descriptions of Virginia Caves,* with maps and descriptions of hundreds of previously undescribed caves. John played major roles in the passage of the Virginia Cave Protection Act and creation of the official state agency, the Virginia Cave Board (and its predecessor the Virginia Cave Commission). He served on the board from 1978 to 1996 and from 2000 to 2012. During this time he was instrumental in developing the first list of "significant caves" for Virginia, roughly 10 percent of the known caves. He was instrumental in the listing of two species on the U.S. Endangered Species List—the Madison Cave isopod and the Lee County cave isopod. John also worked closely with The Nature Conservancy to protect and purchase Unthanks Cave, now a dedicated state natural area. There was hardly any cave conservation activity in the Virginias in which John was not a major player. Less appreciated is the critical role both his biological inventory and cave descriptions played in providing objective information about caves and their significance. The early role of these lists was just to publicize the existence and importance of caves at a time when his was a lonely voice advocating cave protection. Today, these lists continue to be updated, expanded and maintained by those following John Holsinger's lead, and provide the basis for prioritizing cave and karst protection efforts.

The Use of Dye Tracing to Develop a Mitigation and Response Plan for Two Karst-Based Public Water Supplies in Augusta County, Virginia

Denton, Robert K., Jr.*[1] (Robert.denton@terracon.com), Valentino, Joshua D.[1]

[1]GeoConcepts Engineering Inc. a Terracon Company

Construction of buried infrastructure presents potential impacts to karst aquifers upon which local communities depend for drinking water. Therefore, it is important to identify any features that could be insurgences for contaminated water generated by land-disturbing activities. Two public water supplies were identified that could be potentially impacted by the construction of the Atlantic Coast Gas Natural Gas Transmission Pipeline: Gardner Spring, which supplies half the drinking water for the City of Staunton (pop. 24,528); and the well and springs of the Town of Deerfield (pop. 132). Dye tracing established a hydrologic connection between Gardner Spring and a sinkhole located approximately 4.1 miles to the south. Travel time of less than 12 days suggests conduit flow. In contrast, dye placed in a sinkhole closer to the spring was traced to several other locations, but not to Gardner spring. Both injections were within the spring's designated source water protection area, delineated by a consultant using fracture trace analysis, geology, and topography. However, our results show that only the southern point is in the recharge zone for Gardner Spring, and suggest the karst aquifer network in this region contains several discrete hydrogeological compartments. At Deerfield, dye which was placed in the Hamilton Branch above a sink located 0.7 miles to the west was detected at the water supply within 24 hours. Based on these results, we developed a site-specific plan for each water supply to preclude potential impact to the karst aquifer, as well as specific response and notification plans to coordinate with the municipalities dependent on the aquifer for potable water. Our study demonstrates that dye tracing is an essential component of any meaningful delineation of recharge areas in karst.

Cave Management Law, Policy and Implementation in the Philippines

Despain, Joel (jdespain@nckri.org)

National Cave and Karst Research Institute, 400-1 Cascades Avenue, Carlsbad, NM

The Republic of the Philippines has a robust cave and karst management system that can be a model for other nations seeking to protect and manage their cave and karst resources. The Philippine program is based upon the federal Cave and Karst Management Protection Act of 2001 (CKMPA), which is closely linked to other laws including the Indigenous People's Rights Act of 1997, the National Integrated Protected Areas System Act of 1992 and the Tourism Act of 2009. CKMPA is administered by the Federal Department of Environment and Natural Resources (DENR). DENR has developed cave assessment and classification systems and cave conservation and management handbooks, and trained staff in their use and implementation. Information on caves is restricted until assessments have been completed. Philippine and foreign cavers are heavily involved in the implementation of the law and policies. As is true in most countries, there remains a shortage of staff, finances, and other resources to strongly implement all aspects of a cave and karst program.

Lidar-Derived Elevation Models and Imagery as Tools for Karst Feature Mapping and Management

Doctor, Daniel H. (dhdoctor@usgs.gov)

U.S. Geological Survey, 12201 Sunrise Valley Drive, Reston, VA

Management of karst resources begins with an inventory of the geomorphic and hydrologic features that comprise a karst system. The inventory of surface karst features is obtained via examination of surface topography and through field verification. Common challenges to obtaining this inventory are thick vegetation that obscures small landforms, and limited access to remote locations. In 2014, the U.S. Geological Survey (USGS) established the 3D Elevation Program (3DEP) for acquiring airborne light detection and ranging (lidar) elevation across the entire U.S., with base specifications of 1 m horizontal resolution and 10.0 cm or better bare-earth vertical accuracy. Digital elevation models (DEMs) produced from lidar data have since revolutionized the mapping of karst regions, and by extension the scope of their management. Within geographic information system (GIS) software, semi-automated tools have been developed for the digital extraction and morphometric analysis of closed depressions from lidar DEMs. Many more sinkholes (typically tens of percent or more) can be delineated using lidar imagery than by using closed contours on traditional 1:24,000 scale USGS topographic maps. When combined with digital geologic map data, lidar elevation imagery can be used to identify previously unrecognized karst development in geologic units less prone to dissolution. In addition, automated hydrologic routing tools can be employed to define contributing areas to sinkholes and to illustrate ephemeral surface flow paths that are often not represented on traditional topographic maps. Finally, the enhanced visualization of lidar-derived bare-earth topography alone provides an excellent means for public awareness, education, and management of karst regions.

Use of Clarksville Cave Preserve

Engel, Thom (necaver@earthlink.net)

Northeastern Cave Conservancy Inc, 16 Equinox Ct #2A, Delmar, NY 12054

Clarksville Cave is owned by the Northeastern Cave Conservancy (NCC). A popular beginners' cave, it draws visitors from as far west as Buffalo to as far east as Boston, from Québec City to the north to Philadelphia to the south. From April 2012 to April 2014, data were gathered on the nature of the groups visiting the cave. Information gathered included group size and type, and how they were equipped. Additionally, individuals were asked about their affiliations with the NCC and the National Speleological Society (NSS), their knowledge of white-nose syndrome (WNS), and whether the trip was their first wild cave trip. There were many surprising results. The first was that over 20% of preserve visitors only visited the surface. The second unexpected result was that while over half of visitors had heard of WNS, they didn't understand that the goal of decontamination was to stop the spread of WNS from an affected cave to other sites. However, some did say that they understood spores from muddy clothing and equipment could contaminate their vehicles. The third surprise had to do with the affiliation of visitors with caving organizations. Only 8% of visitors belonged to the NCC and less than 12% belonged to the NSS.

Filling the Voids: Cave Conservancy of the Virginias and the Cave Conservancy Foundation

Ficco, Mike (mficco@mindspring.com)

Cave Conservancy of the Virginias/Cave Conservancy Foundation, 13131 Overhill Lake Ln, Glen Allen, VA 23059

There is no shortage of potential projects in the world of cave and karst management and conservation. Many of us have lists of great projects that we'd like to see happen if only we had the resources and/or institutional flexibility to pull them off. For nearly 40 years, the Cave Conservancy of the Virginias (CCV) and the Cave Conservancy Foundation (CCF) have been helping to bridge the voids between the ideas and the execution of those ideas. These two 501(c)(3) organizations accomplish this goal through a combination of grant awards for research and conservation, scholarships, public-private partnerships, and direct purchase/protection/management of properties. CCV owns and manages two significant cave preserves in Virginia, including the state's longest and deepest cave (the Omega Cave System). CCV is negotiating to purchase property that would establish its third significant cave preserve, funded by a grant from the US Fish and Wildlife Service as part of a Natural Resource Damage Assessment (NRDA) settlement pursuant to a nearby industrial site. CCV has also been instrumental in the purchase and protection of many other important cave properties in the Virginias by providing funding, purchasing rights of first refusal, funding biological surveys and hydrological studies, etc. CCF's undergraduate and graduate scholarship programs have assisted dozens of students, helping them become leaders in the field of karst science, some of whom are likely in attendance at the 2019 National Cave and Karst Management Symposium. Moving forward, CCV and CCF endeavor to continue filling their historical roles in the cave and karst conservation communities, while pursuing collaborations and partnerships with other like-minded organizations as a way of adapting to the evolving environment of increased competition for seemingly decreased public funding of science and conservation.

Cave Research When All the Caves Are on Private Land

Futrell, Mike (mfutrellcave@gmail.com)[*1]; Futrell, Andrea[1]

[1]Virginia Speleological Survey, 456 Thistle Lane, Christiansburg, VA 24073

The vast majority of caves in the eastern United States are on private lands. Approaching landowners about access to caves on private property for exploration, research, and conservation requires careful planning and thoughtful interactions. Access to a cave is frequently built upon a personal relationship between the cave researcher and the landowner. It is important to have an understanding of the local culture as well as knowledge of cave laws and landowner liability. Consensus building and communication within the caving community is also essential to maintaining access. Owners initially want to know their potential liability and what's in it for them. Some owners are very interested and curious, others not so much, and a few outright hostile. For the long-term, maintaining a relationship by sharing maps, photos, and research findings is key. Working with cave landowners is unusual because it encompasses understanding agricultural and forestry practices, scientific research, ecology, recreational use, and a diverse group of people. Most speleological knowledge in the eastern US is a direct result of landowners allowing access for cave exploration and related research. Quite often a cave owner will be willing to allow a small group access for mapping and research while not allowing recreational caving. This approach can benefit the researcher as well, as it helps to alleviate concerns that sport cavers could jeopardize access. Increased economic development pressure and climate change related concerns make it even more important to work with cave owners toward a further our understanding of natural systems, including those of the subterranean realm. even more important to work with cave owners toward a further our understanding of natural systems, including those of the subterranean realm.

How Important Are Grottoes to Landowner Relations?

Griffin, Tom (preserves@caves.org)

National Speleological Society Preserve Chairman, Eastern Region Landowner Relations Vice-Chair, 137 Stoney Lick Rd, Martinsburg, WV 25403

While nearly all organized American cavers belong to the National Speleological Society (NSS), Grottoes are the local organizational units (essentially chapters of the NSS) with which most cavers identify. One important role a Grotto can fulfill is that of liaison between cavers and landowners. I would like to go over guidance on how best to first approach a landowner regarding access and other cave-related issues, and on how to follow up and maintain good landowner relations. The NSS landowner relations committee is developing this guidance as a tool that can be used by Grottoes around the country to help improve and maintain landowner relations.

Evaluating Cave Gate Compromises and Reconsidering Alternatives

Holliday, Cory*[1] (cholliday@tnc.org); Kennedy, James Wolfe[2]

[1]The Nature Conservancy, 862 Fort Blount Ferry Rd., Gainesboro, TN 38562; [2]Kennedy Above/ Under Ground, 304 West Mockingbird Lane, Austin, TX 78745

Cave gates are an important and constantly evolving tool to protect caves, the species that live in them, and other resources from anthropogenic threats. Land managers and cave gate builders evaluate potential and observed collateral impacts of cave gates as well as long-term management variables, including cave gate lifespan. A steel fence designed by Roy Powers and recently modified by Jim Kennedy offers a new option that may be preferential for particular caves and entrances. This design was constructed for the first time at an important Tennessee bat cave in the summer of 2019.

Hibernacula Microclimates Mediate Bat Survival with White-nose Syndrome

Hopkins, Skylar*[1] (skylar.hopkins@vt.edu); Hoyt, Joseph[1]; White, J. Paul[2]; Kaarakka, Heather[2]; Redell, Jennifer[2]; DePue, John[3]; Scullon, William[3]; Kilpatrick, A. Marm[4]; Langwig, Kate[1]

[1]Department of Biological Sciences, Virginia Tech, Blacksburg, VA 24060; [2]Wisconsin Department of Natural Resources, Bureau of Natural Heritage Conservation, Madison, WI; [3]Wisconsin Department of Natural Resources, Bureau of Natural Heritage Conservation, Madison, WI; [4]Department of Ecology and Evolutionary Biology, University of California, Santa Cruz, CA

Microclimates vary within and between bat hibernacula and affect bat energy and water conservation during hibernation. Bat survival in the Eastern United States might be especially contingent upon microclimate selection now that *Pseudogymnoascus destructans* (*Pd*), the white-nose syndrome fungus, has invaded the region, because fungal growth is strongly temperature-dependent. To test this hypothesis, we visited 22 hibernacula in Michigan and Wisconsin during early (November) and late (March) hibernation from 2014-2019—before, during, and after fungal invasion. During each visit, we quantified individual bats' roosting temperatures, fungal loads, and survival, focusing on a historically common bat species (*Myotis lucifugus*). We found that fungal growth rates were higher on bats that roosted in relatively warm microsites, and correspondingly, bats roosting in warm microsites were less likely to survive the winter. At the regional scale, average bat roosting temperatures declined 1ºC from pre- to post-invasion, because colder hibernacula served as thermal refugia from disease impacts. However, despite this strong selection pressure, the majority of bats continued to roost at the warm temperatures associated with low bat survival. Managing microclimates that serve as ecological traps, sinks, and refugia might mediate future bat population declines due to white-nose syndrome.

Use of Time Lapse Photography to Monitor Seasonal Ice Formation in Castleguard Cave, Alberta, Canada

Horne, Gregory*[1] (greghorne.work@gmail.com); Graham, Kathleen[2], Critchley, David[3]

[1]Alberta Speleological Society, Box 2202, Jasper, Alberta, Canada; [2]Alberta Speleological Society, 2307 16 St. SE, Calgary, Alberta, Canada; [3]Northern Alberta Institute of Technology, 11762 106 St. NW, Edmonton, Alberta Canada

Canada's longest cave, Castleguard, has provided past and present generations of cavers with unexpected seasonal ice and hydrology surprises that block or threaten access to the cave. During early days of exploration in the 1960's, summer flooding quickly shifted caving activity to late winter and early spring, when water levels in the cave were the lowest. By the mid 2000's cave hydrology was changing. Massive summer flood events occurred and thick ice built up that prevented access. Conditions are now so unpredictable that pre-expedition reconnaissance visits are mandatory to check if the cave is enterable. Even with this level of preparation, groups frequently turn back due to rapid changes in only a couple weeks between visits. In 2015, Graham initiated a project to monitor ice levels in Castleguard. Initially each monitoring session involved a 40 km round trip ski on a glacier, whiteout conditions and avalanche hazards. But because of the ice blockage the novelty of measuring ice thickness and not being able to actually do any caving faded and led to an alternate monitoring method, time lapse photography. The monitoring site requires equipment for unattended operation of a year, underwater housing for 15m depth, and tolerance of both below freezing temperatures and powerful summer flood pulses, all with a shoestring budget. As a bonus, time lapse monitoring of the entrance resurgence activity can be captured. Collection of temperature data outside and in the cave is combined with photography. Could roadside weather data be a proxy to predict cave ice levels without a pre-expedition visit?

Miniaturization of Temperature Data Logger and Enhanced Recovery Technique of Bats in Hibernacula

Horne, Gregory*[1] (greghorne.work@gmail.com), Olson, Cory[2], Critchley, David[3], Lausen, Cori[4]

[1]Wildlife Conservation Society Canada, Box 2202, Jasper, Alberta, Canada; [2]Wildlife Conservation Society Canada, Edmonton, Alberta, Canada; [3]Northern Alberta Institute of Technology, 11762 106 St. NW, Edmonton, Alberta, Canada' [4]Wildlife Conservation Society Canada, P.O. Box 606, Kaslo, British Columbia, Canada

As part of a White-nose syndrome survivorship modelling project, an alternate method of collecting temperatures of hibernating bats was designed and tested using two commercially available products originally marketed for far different applications. The temperature measurements are collected by a small data logger called iButton (https://www.ibuttonlink.com). Without modification these data loggers would be too heavy for the targeted bat species, Little Brown Myotis *(Myotis lucifugus).* The stainless steel case was removed and the circuit board trimmed to shed as much weight as possible. To assist with recovery of the iButton, a Recco reflector (http://www.recco.com) was added. Recco reflectors were originally designed to assist with locating avalanche victims. To the iButtons we attached the company's ultralight version, which is small enough that it can be used to help track insects. At two hibernacula in western Canada the experimental design was tested. One site was an abandoned mine and the other a limestone cave. During a winter visit, bats were removed from their roosting spot, hair on their back trimmed and the iButton/Recco combination secured with veterinary glue. After full arousal, each bat was released to fly. After three months the sites were visited again to recover the temperature data loggers. Visual searches for bats with data loggers (yellow plastic dipped instrumentation) and the use of a Recco specific receiver located varying numbers of bats with loggers. Recovery was better in the cave than the mine where metal debris may have hindered the Recco search. In a cave setting this technique is very promising.

Using Show Cave Lights as a Cave Management and Interpretive Tool

Horrocks, Rodney D. (rod_horrocks@nps.gov)

Cave Management Specialist, Carlsbad Caverns National Park, 3225 National Parks Highway, Carlsbad, NM 88220

Lighting systems in show caves can do much more than just facilitate visitation. Cave lights can be used to address multiple cave management issues at the same time that they are used to highlight or reveal cave features. Lights can be used to address public and employee safety, eliminate disability glare, allow two-way traffic, increase ambient light levels to meet OSHA safety standards, reduce lampenflora growth, discourage vandalism, and lower energy consumption. At the same time, lights can be a valuable interpretive tool that allows greater flexibility in how interpreters/guides present a cave to visitors. Individual lights can be turned on to direct visitors' attention to specific natural or cultural features. Light shows, consisting of groups of lights that are turned on in a sequence, can be used to reveal spectacular features or scenes within a cave. The cavern darkness experience can be used to educate visitors about the true nature of caves. Instead of treating the cave like a building interior, cave lights can be designed to preserve the intrinsic nature of caves by utilizing dimly lit or totally dark areas, especially for redundant features or unimpressive areas,. Lights can address visual effect and atmosphere by utilizing texture, contrast, color, shadows, and blackness to evoke mystery and beauty. When a new cave lighting system is originally designed or when one is replaced due to age, each of these topics should be addressed to maximize the potential benefits of using lights in a show cave.

Butler Hollow Cave Project

House, R. Scott*[1] (scott_house@hotmail.com); Cooley, James[2]

[1]Cave Research Foundation, 1606 Luce St., Cape Girardeau MO 63701; [2]819 W 39th Terrace, Kansas City MO 64111

The Butler Hollow Project is a five-year project to gate unsafe cave entrances that were part of mining/ore-prospecting projects some decades ago. Bat-friendly gates have been built on twelve cave entrances. Cultural assessment, cave mapping, and biological inventory have been done on all project caves. Additional caves on the Cassville subdistrict, Mark Twain National Forest have also been investigated, mapped, and inventoried as part of a search for more disturbed caves.

The Missouri Cave Database

House, R. Scott*[1] (scott_house@hotmail.com); Grush, Ken[2]

[1]Cave Research Foundation, 1606 Luce St., Cape Girardeau MO 63701; [2]Missouri Speleological Survey, 32 Circle View Drive, Fenton MO 63026

The Missouri Cave Database is an outgrowth of a 50-year effort by the Missouri Speleological Survey (MSS) to document cave and karst information in the state. The present database was initiated as a small effort in the late 1980's and eventually incorporated thousands of records from the old Cave Catalog, a joint effort between the MSS and Missouri Geologic Survey. Today the database has expanded into a relational database with more than 7500 main table records. Additional descriptions, trip reports, and other materials comprise yet another 17,000+ records. Map records number more than 5500 while biological occurrences in caves comprise over 33,000 records.

Cave and Bat Management on Ozark National Scenic Riverways

House, R. Scott*[1](robert_s_house@partner.nps.gov); Houf, Kim[2]

[1]Cave Research Foundation, 1606 Luce St., Cape Girardeau MO 63701; [2]National Park Service, Box 490, Van Buren MO 63965

The Ozark National Scenic Riverways (National Park Service (NPS)) has over 400 caves within its authorized boundaries. Most of those are on fee-simple land (NPS owned). Active management of the caves involves constant monitoring, bat censuses, biological inventories, mapping, and cave gate building and maintenance. To accomplish this, the NPS partners with and helps to fund park activities of the Cave Research Foundation (CRF), which provides qualified volunteers and part-time professional labor.

The Butler Hollow Project in Missouri

House, R. Scott[*1] (scott_house@hotmail.com); Sutton, Michael[2]

[1]Cave Research Foundation, 1606 Luce St., Cape Girardeau MO 63701; [2]5544 County Road 204, Annapolis MO 63620

The Butler Hollow area on the Mark Twain National Forest (MTNF) in Barry County, Missouri is not an orthodox mining district – the past mining activity is a remarkable story of fraud and naivety involving at least five caves, in a highly unlikely search for radium and perhaps silver as well. The activity left several caves with artificially excavated entrances and passages, which can be hazardous to the public. Because of this past use, the US Forest Service classifies these mostly natural caves as mines, and are obligated to control access for public safety. Since most of the caves house bat populations, bat-friendly gates were required. MTNF entered into a cost-share agreement with Cave Research Foundation to not only gate the mined caves, but to also search for other potential mining sites on the Cassville sub-district and to perform mapping and biological survey of caves throughout the sub-district. The project began in 2014. Gating, headed by Jim Cooley, began in October 2015 and was completed in June 2019, with the construction of 12 bat gates on four caves and one mine. The project has also resulted in a thorough documentation of caves throughout the sub-district. Of the 147 known caves, more than 80 were first recorded during this project. Most of the caves are small, but range up to 2600 feet (800 m), and include many biologically and archeologically significant sites.

Comprehensive Biodiversity Inventory of the Fern Cave System at Fern Cave National Wildlife Refuge, Jackson County, Alabama

Inebnit, Thomas*[1] (thomas_inebnit@fws.gov); Niemiller, Matthew L.[2]; Slay, Michael E.[3]; Hinkle, Amata[4]; Jones, Bradley D.[5]; Jones, Mark[4]; Lamb, Joseph[6]; Mann, Nathaniel[4]; Miller, Benjamin[7]; Pattavina, Pete[8]; Pinkley, Jennifer[4]; Pitts, Steve[4]; Richardson, David[9]; Sapkota, Kayla N.[10]

[1]Arkansas Ecological Services Field Office, U.S. Fish and Wildlife Service, Conway, AR: [2]Department of Biological Sciences, The University of Alabama in Huntsville, Huntsville, AL: [3]Arkansas Field Office, The Nature Conservancy, Little Rock, AR, [4]Southeastern Cave Conservancy, Inc., Signal Mountain, TN; [5]Birmingham Grotto, Trussville, AL; [6]Department of Biological and Environmental Sciences, Alabama A&M University, Huntsville, AL; [7]Lower Mississippi Gulf Water Science Center, U.S. Geological Survey, Nashville, TN; [8]Georgia Ecological Services Field Office, U.S. Fish and Wildlife Service, Athens, GA; [9]Inventory and Monitoring Branch, Division of Refuges, U.S. Fish and Wildlife Service, Grenada, MS; [10]Department of Business, Arkansas State University at Beebe, Beebe, AR

The 199-acre Fern Cave National Wildlife Refuge (NWR) is part of the Wheeler NWR Complex and is located in the Paint Rock River valley in western Jackson County, Alabama. Fern Cave is the largest cave system (>15 miles) in Alabama and is the largest known hibernaculum for the federally-endangered Gray Bat (*Myotis grisescens*). Although records exist for several additional vertebrate and invertebrate species, there has never been a comprehensive biological inventory conducted of the Fern Cave system. We began a two-year bioinventory study of the cave system in June 2018, implemented by the Inventory & Management Branch of the U.S. Fish & Wildlife Service, to better understand the Fern Cave system and its fauna. To date, 20 biologists and cavers have cooperatively conducted five biological survey trips (2018: June, August, December; 2019: February, July) to Fern Cave NWR covering a majority of cave passages. We have documented over 80 morphospecies in 5 phyla, 15 classes, and 33 orders, including 73 terrestrial and 11 aquatic species. At least 24 species are cave-obligates (troglobionts and stygobionts), and two and four species are federally-listed and state-priority species, respectively. Significant observations include Torode's Cave Pseudoscorpion (*Tyrannochthonius torodei*), an undescribed cave millipede, and the discovery of a new population of the federally endangered Alabama Cave Shrimp (*Palaemonias alabamae*). Fern Cave is now tied with Shelta Cave for having the highest number of cave obligate species in TAG.

The Mid-Atlantic Karst Conservancy

Jahn, Jeff (pghrocks@comcast.net)

1026 Lakeview Drive, Cross Junction, VA 22625

In 1997, eleven cavers each contributed $10 to establish the Mid-Atlantic Karst Conservancy (MAKC) as a non-profit corporation in western Pennsylvania. MAKC's mission is the study, conservation, and preservation of caves and karst resources, and education of the public about those resources. MAKC now owns three preserves, leases six, and collaborates with other individual owners and public agencies to manage over 5,000 acres of karstlands including over 40 caves. In 2009 MAKC established the Bob and Bev Danielson Library and Education Center in Blairsville, PA in honor of its benefactors, creating a key focal point for karst education housing an extensive collection of domestic and international caving books and periodicals donated by cavers, including Jack Speece, the late Dale Ibberson, the late Jack Stellmack, and the York Grotto. 2019 was a banner year for MAKC, which used grants and donations to establish the Barbara Schomer Preserve, in honor of a long-time supporter of MAKC and Pittsburgh Grotto, to protect Sarah Furnace cave, a Van Port limestone cave with potential to be the longest in PA. MAKC also leased West Virginia's Silers Cave, a favorite among cavers from the Philadelphia, Baltimore, and DC areas, that had been closed for over a decade, then recently purchased by a caver willing to allow MAKC to manage access. A new survey is underway. Finally, MAKC is helping to manage Rupert cave in central PA, which has a pristine section limited to a few guided trips annually. The owners reached an arrangement with MAKC to lead trips when they are unable to do so. MAKC's strong membership is well positioned to meet challenges that include raising adequate funds and continuing to purchase or negotiate access to caves.

Hydrologic connections between precipitation, dripwater and stream discharge in James Cave, Virginia

Junod, Megan*[1](meganj2@vt.edu); Schreiber, Madeline[1]; Kosič Ficco, Katarina[2]; Malabad, Thomas[2], Orndorff, Wil[2]

[1]Dept. of Geosciences, Virginia Tech, Blacksburg, VA 24060; [2]VDCR Natural Heritage Karst Program, 8 Radford Street, Suite 102A, Christiansburg, VA 24073

In 2007, we instrumented James Cave in Pulaski Co., Virginia to study the hydrologic connections between precipitation, dripwater and the cave stream with the goal of delineating mechanisms and quantifying rates of recharge to the karst aquifer. Currently, we have collected almost 12 years of high-frequency measurements, including relative dripwater rates and absolute stream discharge. Dripwater rates are measured on 10-min intervals using suspended tarps draining to rain gauges. Stream discharge is calculated using pressure transducers that log stream depth behind a V-notch weir. For this project, we compare the datasets of precipitation, dripwater rates and stream discharge rates to evaluate hydraulic connections and patterns of recharge. From 2007 to 2018, aquifer recharge occurred only during 3 to 5 month periods ending each May. In 2018-19, a year with record precipitation, recharge lasted over 8 months. We are also evaluating connections between precipitation, dripwater rates and stream discharge to compare patterns of diffuse and direct recharge. Another goal of this project is to create and maintain a long-term cave hydrology dataset in the public domain. To do this, dataloggers in the cave are downloaded monthly to bimonthly and are processed through instrument software (Hoboware) to screen for data quality and to check for instrumentation failure. After processing, datasets are merged using either time series software or R. All raw and processed data are maintained in shared folders in the cloud. Data are periodically published and made available to the public via VTechWorks, a Virginia Tech data repository.

A Geochemical Comparison of Two Telogenetic Karst Springs During Reverse Flow, Mammoth Cave, Kentucky

Kambesis, Pat*[1] (pat.kambesis@wku.edu); Kipper, Chelsey[1]

[1]Center for Human and Geoenvironmental Studies, Department of Geography and Geology, Western Kentucky University, 1906 College Heights Boulevard, Bowling Green, KY 42101

Previous studies in Mammoth Cave National Park have identified a phenomenon, referred to as *stable reverse flow*, that may significantly contribute to cave formation. Groundwater in the Mammoth Cave Karst Aquifer typically discharges from springs into the Green River, the regional hydrologic base level. When the river stage increases, water from the Green River enters River Styx Spring, flows over the drainage divide, and discharges at Echo River Spring. This study quantified the geochemical and hydrologic changes that occur between the two springs during stable reverse flow. The stage of the Green River, influenced by storm events in the Upper Green River Basin, seasonal changes associated with evapotranspiration, and damming along the Green River, control the timing and duration of stable reverse flows. Data were collected to capture seasonal changes in karst geochemistry, flow rates, groundwater sources, and carbon transport in the karst system. Major ion concentrations, alkalinity, TOC and carbon isotopes were collected weekly; SpC, temperature, and pH were recorded at 10-minute intervals; and pressure transducers were used to collect water levels at two-minute intervals. Data showed the relationships between stable reverse flows, meteorological processes, and human influence on the river basin. Distinct changes in geochemical parameters were used to determine when flow reversals occur. Alkalinity, TOC, and carbon isotope measurements provided information about seasonal and temporal changes in carbon flux, and about how spring flow reversals contribute to carbonate dissolution and conduit development.

A Unified Interdisciplinary Approach for the Protection of Karst Aquifers

Kosič Ficco, Katarina*[1] (katarina.kosic@dcr.virginia.gov); Sasowsky, Ira D.[2]

[1]Department of Conservation and Recreation, Natural Heritage, Karst Protection Program; [2]University of Akron, Department of Geosciences, OH

Karst aquifer assessment and management require site-specific approaches due to the varying character and extreme susceptibility to contamination of these aquifers. An exhaustive study of legislative and scientific aspects of karst aquifer protection has shown that inclusion of various entities, e.g. legislative bodies, scientists, the public and various other stakeholders is of great importance. Interjurisdictional protection can be hampered by confusing methodologies and guidelines that result from a lack of cooperation between stakeholders and from differences between regulatory and legislative systems. These issues could be solved by adopting unified procedures and approaches. A new interdisciplinary framework for karst aquifer protection and management proposes a generalized approach, which can be used regardless of the regulatory environment, terrain, and hazards. This K-framework provides guidelines for carefully structured cooperation between domains that are, or need to be, involved in karst aquifer protection: e.g. karst scientists, other scientists, regulators, policy-making bodies, the public, and various other stakeholders. The presented framework is based on levels of knowledge that each of these parties can contribute to the process, and can be used for developing site-specific assessment guidelines for karst aquifers as well as protection policies on the national and international levels. By following the straightforward guidelines provided in this framework, management and protection of karst aquifers can be significantly improved without major changes to existing methodologies or regulatory and legislative practices.

Creating a High-Resolution Simulation of the Timpanogos Cave System Using a Terabyte Scale LiDAR Dataset.

LaSala, Blase*[1] (blase.lasala@gmail.com); Kemeny, John M.[1]; McKinney, Cami[2]; Armstrong, Andy[2]; Levine, Joshua Aaron[3]; Swetnam, Tyson[4]; Kazhdan, Misha[5]; Steele, Nicholas[6]; Swift, Kelly[2]; Bahr, Kirsten[2]

[1]Mining and Geological Engineering, University of Arizona, 1235 James E. Rogers Way, Tucson, AZ; [2]National Park Service, Timpanogos Cave National Monument, 2038 Alpine Loop Rd, American Fork, UT; [3]Department of Computer Science, University of Arizona, 1040 E. 4th Street, Tucson, AZ; [4]Data Science Institute, University of Arizona, 1230 N Cherry Ave, Tucson, AZ; [5]Department of Computer Science, John Hopkins University, Whiting School of Engineering, 3400 N Charles St, Baltimore, MD; [6]National Park Service, Grand Canyon National Park, Grand Canyon, AZ

Point clouds are a widespread method for digitizing real world objects. While this is in-part thanks to advancements in technology and lowering cost of equipment, the ability to render large mesh datasets at high resolution has been limited by hardware. This limitation can make these data difficult to utilize unless the resolution is reduced, which results in a loss of small-scale features. However, when it comes to underground spaces such as caves, the preservation of these small-scale features can be vital for geological characterization, safety, and resource management. In 2015 and 2019, a 22-billion-point cloud of the Timpanogos Cave system was collected using 520 terrestrial LiDAR scans. Its resolution is high enough to resolve sub-centimeter scale cave formations, such as helictites and soda straws. A Cooperative Ecosystems Studies Units (CESU) agreement between the University of Arizona and Timpanogos Cave National Monument was enacted in 2018 to develop this terabyte scale dataset into an interactive simulation for use in research and public outreach. The methodology and challenges processing this dataset are summarized. Using high-performance computing (HPC) solutions, python scripting, and meshing algorithms adapted for clouds exceeding several billion points, a model that preserves the delicate formations for which the system is famous can be rendered using today's hardware. A beta version of Timpanogos Virtual will be featured, allowing users to explore the cave system in virtual reality. A live demo for audience members to try after the talk may also be made available.

Endangered Species Management in an Era of Ever-Increasing Biodiversity: A Case Study of the Molecular Phylogenetics of *Lirceus hargeri*

Lewis, Julian*[1] (lewisbioconsult@aol.com); Lewis, Salisa[1]; Orndorff, William[2]; Malard, Florian[3]; Douady, Christophe[3]; Konecy, Lara[3]

[1]Lewis and Associates, Biological Consulting, 17903 State Road 60, Borden, IN 47106; [2]Virginia Department of Conservation and Recreation, 8 Radford Street, Christiansburg, VA; [3]Laboratoire d'Ecologie des Hydrosystèmes Naturels et Anthropisés, Université Lyon 1, Lyon, FRANCE

Until 2015, in Lee County, Virginia, two species of the isopod *Lirceus* were known: the federal endangered Lee County cave isopod *Lirceus usdagalun*, and a poorly known inhabitant of springs, *Lirceus hargeri*. As an endangered species, *Lirceus usdagalun* received intensive attention to discover populations and establish its range, while *Lirceus hargeri* remained in obscurity. In 2016, at the Smithsonian Institution, the type-specimens of *Lirceus hargeri* were examined with the realization that the genital pleopod morphology of this spring species was identical to that of *Lirceus usdagalun* and its stygobiont sister species *Lirceus culveri*. Continued research revealed the range of *Lirceus hargeri* extends from southwestern Virginia through eastern Tennessee into northern Georgia. A new collaboration with French colleagues spurred collection of fresh specimens of *Lirceus hargeri* from across its broad range for molecular phylogenetic analysis. The results revealed the presence of many more molecular taxonomic operations units of *Lirceus* in Lee County as well as across the range of the *hargeri* morphospecies. Work has begun on translating molecular species into morphological species descriptions. Descriptions have been prepared for two new species of stygobiont *Lirceus* endemic to Washington and Tazewell counties, Virginia, as well as several other new species endemic to karst spring basins. The new challenge is how to manage this complex of species with the realization that several of them are rarer, and more vulnerable, than the listed endangered species. The stygobite from Washington County, known only from specimens collected in 1967, appears to be extirpated from its only documented location and may already be extinct.

Sinkholes: Biodiversity Hotspots of Epigean Terrestrial Karst Ecosystems

Lewis, Julian*[1] (lewisbioconsult@aol.com); Milne, Marc[2]; Stephen, Charles[3]; Dunlap, Keith[4]

[1]Lewis and Associates LLC, Biological Consulting, 17903 State Road 60, Borden, IN 47106; [2]Department of Biology, University of Indianapolis, Indianapolis, IN 46227; [3]Department of Biological Sciences, Auburn University, Auburn, AL 36849; [4]Indiana Karst Conservancy, P.O. Box 2401, Indianapolis, IN 46206

Sinkholes are ecotones in karst ecosystems that connect surface communities to underlying caves. Because of their habitat heterogeneity and buffered environments, sinkholes are biodiversity hotspots. Between 2015 and 2017, 26 sinkholes found in 12 tracts of the Hoosier National Forest were surveyed for fauna during 104 visits. Measurement of their physical dimensions and environmental parameters included temperature and relative humidity. Organic matter was weighed in a 0.25m^2 quadrat area of the sinkhole floor and the invertebrates present collected. We selected five target groups for detailed identification: terrestrial snails, terrestrial isopods, spiders, pseudoscorpions and millipedes. A total of 131 species were identified including species previously known only from caves such as pseudoscorpions *Kleptochthonius griseomanus*, *Chitrella* spp., and the millipede *Conotyla bollmani*. Also discovered were new state records for several species, e.g., the millipede *Cleidogona unita* and spider *Phrurolithus singulus*. Faunal diversity was positively correlated with the quantity of deciduous forest leaf litter on the sinkhole floor. Sinkholes in fields or pine plantations had lower biodiversity than those in deciduous forests. Sinkholes floors had temperature and relative humidity intermediate between surface and cave environments. During the summer, all sinkholes were cooler than the surface and humidity was higher, with some sinkhole floors approaching the temperature of caves (around 55° F) and saturated humidity of 100%. In winter temperatures dropped, but were less variable than the surface and remained higher than the ambient surface temperatures during the coldest days.

Cavers Conserving Karst: The Indiana Karst Conservancy

Lewis, Salisa[*1] (thefirstfeed@gmail.com); Lewis, Julian[1]

[1]The Indiana Karst Conservancy. 17903 State Road 60, Borden, IN 47106.

The Indiana Karst Conservancy (IKC) is a nonprofit organization dedicated to preservation and conservation of caves, springs, and karst features, including their archaeological, biological, and geological significance. Karst protection includes land acquisition, conservation management, research, and education. The IKC pursues targeted acquisitions, obtains multiple avenues for funding, and partners with conservation agencies (The Nature Conservancy, the National Speleological Society (NSS)). After acquisition, the IKC establishes a stewardship fund, a property manager, and a cave patron. The IKC then develops a management plan and liability waiver unique to each property. The IKC owns seven cave entrances and springs on more than 250 acres. Through partnerships with state and private landowners, the IKC manages several additional conservation easements and karstlands. The IKC pursues opportunities for karst conservation through community outreach and education. Examples of this include newsletters, caving opportunities for grottos, and trips to encourage environmentally compatible use. Meetings and partnerships with state, federal and local agencies offer opportunities for land management, research, and education. Education, outreach, and karst management are positive activities supporting cave conservation. These activities encourage member participation. However, the IKC also faces challenges. These include liability, vandalism, and trespassing, as well as recruitment, retention, and member engagement. A major area of opportunity for members is outreach and collaboration with grottos, clubs, and other conservancies. Historically, little communication occurs between cave owners, cavers, and other karst conservancies. The National Cave and Karst Management Symposium provides an excellent forum for discussion between conservancies, owners, and other interested parties.

Improvements for Access to Edgewood Cavern in Central New Mexico

Lyles, John T. M. (jtml@vla.com)

PO Box 95, Los Alamos, NM

In 1970, a cave was discovered by a well driller in Edgewood, 30 minutes east of Albuquerque, NM, in the Pennsylvanian Madera limestone, which occurs only in the subsurface in the area and which commonly produces blowing wells when penetrated by drilling. The landowner and driller dug a shaft using a cable tool rig and a large homemade bit. This 38-meter deep shaft was cased, and cavers were called in to dig into the passages beyond a blowing crack at the bottom. Eventually, they succeeded and Edgewood Cavern became a local curiosity. Though the owner continued into the current millennium to market 5 acres with the cave for one million dollars, it never became the commercial enterprise he hoped for. The 0.5 m (19.5 in) diameter entrance shaft didn't help, although visions of billboards along I-40 kept the dream alive. Cavers explored and mapped about 5 miles of passages, finding extensive joint-controlled morphology and significant fossil exposures. The cave was always at risk from renters and was a safety concern. The author became interested in 2002 and worked with the owner to obtain limited access. Newspaper reports and published scientific work (e.g. Polyak and Asmerom, 2005) resulted from the renewed interest. In 2017, the landowner transferred ownership of the property to the author. Since 2018, there has been significant work cleaning up the property, fencing, and building a permanent structure over the entrance of the cave for further protection. The author (landowner) will continue to permit opportunities for cave science and exploration.

Inventorying Broken Speleothems to Quantify Visitor Impacts in Carlsbad Cavern, New Mexico.

Lynch, Erin – presenting author

Mildice, Aria[1]; Tholen, Jake[2]; Lynch, Erin Margaret[*1] (speleology.erin@gmail.com)

[1]Carlsbad Caverns National Park, 3225 National Parks Highway, Carlsbad, NM; [2]345 Valley Meadow Lane, West Fowlerville, MI

Broken speleothems are an important indicator of visitor impact. Since 1975, broken speleothem inventories have been conducted in Carlsbad Cavern at irregular intervals, with the last in 1993. In 2019 a systematic method was devised for counting, classifying, and permanently marking breaks within 10 feet of the visitor trail. A total of 11,434 new breaks were identified for the 26-year period between 1993 and 2019, approximately 439 breaks per year. Popcorn breaks composed 65% of all breaks found in 2019. Due to the long time period between counts, it is impossible to correlate breakage patterns with most changes in management. However, the Kings Palace and Scenic Rooms route was designated as a ranger-guided tour in 1992, and there has been a notable decrease in the annual breakage rate from 715/year (1988-1993) to 160/year (2019-1993).

Conservation Assessment of Natural Heritage Cave Resources in Virginia: Phase 1, New River Karst Region

Malabad, Thomas[1] (Tom.Malabad@dcr.virginia.gov); Kosič Ficco, Katarina[1]; Orndorff, William[1]

[1]Department of Conservation and Recreation, Division of Natural Heritage, Karst Program, 8 Radford Street, Suite 102A, Christiansburg, VA 24073

The Virginia Department of Conservation and Recreation Natural Heritage Program (DCR-DNH) designates Conservation Sites as geographic areas where activities might be expected to impact Natural Heritage Resources - rare plants, animals, natural communities, or geologic features. These include caves associated with rare, threatened, and endangered animals and/or designated Significant by the Virginia Speleological Survey (VSS) on behalf of the Cave Board, an advisory body established by the VA Cave Protection Act of 1979. Conservation Sites have no independent legal standing, but rather are used by DCR-DNH as a critical screening tool for environmental project review and prioritization of conservation efforts. Sites are prioritized by biodiversity significant rankings (B-ranks) based on the number, rarity, and viability of biological resources. DCR-DNH screens over 300 projects annually for karst concerns, mostly due to proximity to Conservation Sites. Impacts to many caves have been avoided or reduced. DCR-DNH developed many of the cave-related Conservation Sites in the early 2000's based largely on desktop review using cave maps, geologic and topographic maps, and dye traces. However, as of 2017, a third of Virginia's ~ 370 designated Significant Caves had no biological records and were assigned low B-ranks, and data on many other caves was incomplete or too old to be useful. DCR-DNH is undertaking a multi-year effort to update cave-related Conservation Sites state-wide, starting in the New River Karst Region of Virginia - Bland, Craig, Giles, Montgomery, Pulaski, Roanoke, Tazewell and Wythe counties. We aim to improve the accuracy of Conservation Sites through new and updated biological inventory, assessment of habitat and threats, and verification of cave locations, ownership, and conservation status.

Recharge Area Delineation for Manitou Cave to Aid in Threat Assessments for Sensitive Stygobionts

Miller, Benjamin Verlinden (bvmiller@usgs.gov)

U.S. Geological Survey, Lower Mississippi-Gulf Water Science Center: 640 Grassmere Park, Ste. 100, Nashville, TN

When the U. S. Fish and Wildlife Service (USFWS) is tasked with determining whether to add a species to the Endangered Species List, among the primary factors considered are potential threats to the species. In 2010 the USFWS was petitioned to list the Manitou Cave Snail, (*Antroribis breweri*), a stygobiont endemic to Manitou Cave in northeastern Alabama. In karst areas, knowing the recharge area for a cave or spring is critical to identifying potential threats because of surface-groundwater interconnectivity and the resulting influence of surface activities on groundwater quality/quantity. With regards to Manitou Cave, potential threats may include recent subdivision developments, a nearby active quarry, land clearing, and several major highways. The 1.7 km-long cave is currently owned and managed by a non-profit organization, Manitou Cave of Alabama, that oversees management, restoration, research, and documentation. In 2016, talks began between state and federal agencies with the new management in an effort to initiate new research and to determine whether the snail merited listing. In 2019, a cooperative project between the USFWS and the U.S. Geological Survey was started to delineate a recharge area for Manitou Cave through dye tracing. The current research will be used by the USFWS to identify primary threats and to aid in determining whether to list the Manitou Cave Snail.

Using Environmental DNA for the Detection and Monitoring of Groundwater Life: A Case Study on Cave-Dwelling Decapods in Northern Alabama.

Niemiller, Matthew L.*[1] (matthew.niemiller@uah.edu); Dooley, Katherine E.[1]; Boyd, Spencer[1]; Guillemette, Abigail[1]; Sparrow, Summer[1]; Niemiller, K. Denise Kendall[1]

[1]Department of Biological Sciences, The University of Alabama in Huntsville, Huntsville, AL

Despite the importance of aquifers to humans, our knowledge of groundwater biodiversity remains limited, as subterranean habitats are particularly challenging to access and study. Most of the >450 described stygobionts in the United States and Canada have highly restricted distributions, and, consequently, are of conservation concern and at an elevated risk of extinction. The analysis of environmental DNA (eDNA) from water samples collected from springs, caves, or wells offers an exciting and potentially effective way to detect and monitor groundwater biodiversity that might otherwise be difficult or impossible to survey using traditional approaches. eDNA is an increasingly common method of monitoring biodiversity, including threatened and endangered species, that does not require actual capture of the organism but rather relies on detecting the organism's DNA in its environment. Here we discuss the development, implementation, and performance of eDNA as a tool for detection and monitoring of groundwater taxa. We highlight recent studies on groundwater crustaceans in northern Alabama, including the Alabama Cave Shrimp (*Palaemonias alabamae*), a federally endangered species known from just five cave systems, and two cave crayfishes of state conservation concern: Sweet Home Alabama Cave Crayfish (*Cambarus speleocoopi*) and Lacon Exit Cave Crayfish (*C. laconensis*). eDNA can provide a foundation for future studies complementary to traditional survey approaches to gather vital insights into the distributions of rare and threatened groundwater organisms and better inform conservation and management decisions.

Virginia Update on Linear Energy Projects Crossing the Appalachian Karst: Atlantic Coast and Mountain Valley Natural Gas Transmission Pipelines

Orndorff, Wil[*1] (Wil.Orndorff@dcr.virginia.gov); Malabad, Tom[1]; Kosič Ficco, Katarina[1]

[1]Virginia Department of Conservation and Recreation (VDCR), Natural Heritage Karst Program, 8 Radford Street, Suite 102A, Christiansburg, VA 24073

The Mountain Valley (MVP) and Atlantic Coast (ACP) pipelines began construction in early 2018 to transport shale gas from the Appalachian plateau to the Eastern seaboard. Progress was slowed by legal and regulatory obstacles. Both cross the Appalachian Ridge and Valley province where exposures of Paleozoic carbonate bedrock host extensive and biodiverse caves, sinkholes and sinking streams, and aquifers connected to wells and springs. Each project produced karst hazard assessments and mitigation plans, and dye tracing by consultants and VDCR informs monitoring. ACP construction has not begun in Virginia, where Terracon performed dye traces in three areas and is monitoring a karst spring public water supply. Much of MVP in Virginia is completed, but not much on karst. Sediment was discharged to sinkholes due to failure of erosion control devices (ECDs) specified in approved plans along a now nearly completed 4-mile stretch, likely contributing to turbidity at a spring, fortunately not a water supply. Upgraded ECDs worked and are specified for karst moving forward. Trenching created a swallet traced to the same spring and subsequently mitigated with an inverted filter. Several small sinkholes and soil pipes occurred in the construction area, including a swarm of sinks in an area blasted but not excavated, which in conjunction with epikarstic surfaces on excavated overburden led some observers to characterize the area as an “unroofed cave.” Barriers to karst protection in these projects were lack of both pre-existing dye trace data and pre-construction monitoring requirements for springs, in conjunction with the inability to access properties remote from construction with potentially vulnerable karst features. Additional turbidity monitoring of springs is underway.

Using the Bat Call Data Recorder as a Smart Alternative for Monitoring Bat Activity Levels: Examples from Gray Bat (*Myotis grisescens*) Summer Roosts in Virginia

Orndorff, Wil[*1]; Messina, Tony[2]; Malabad, Tom[1]; Kosič Ficco, Katarina [1]; Reynolds, Rick[3]; Powers, Karen[4]

[1]Virginia Department of Conservation and Recreation (VDCR), Natural Heritage Karst Program, 8 Radford Street, Suite 102A, Christiansburg, VA 24073; [2]5452 Painted Gorge Drive, Las Vegas, NV 89149; [3]Virginia Department of Game and Inland Fisheries, 517 Lee Highway, Verona, VA 24482; [4]Department of Biology, Box 6931, Radford University, VA 24142

The Bat Call Data Recorder (BCDR) is a low cost, limited production device that samples the ultrasonic environment to detect, measure, categorize and log bat call activity. The BCDR measures low, high, and average frequencies and duration of each sample. If samples group in a way consistent with bat calls, they are accumulated to determine the activity level within the user defined logging interval. Number of events, frequency and duration ranges, temperature, and battery voltage are written to text file. Minimal deployment requires an SD card and 12 volt battery. Spare battery, charger, and SD card are recommended. Setup with a 9 Amp-Hour Gel Cell allows monthly deployments with a 50% monitoring cycle for around $200. Since 2017, VDCR, VDGIF, and Radford University biologists have used BCDRs to monitor summer colonies of Gray bats (*Myotis grisescens.)* While the BCDR neither records nor identifies species from calls, it offers other performance advantages. Bat activity can be processed quickly and patterns analyzed at scales ranging from single emergence to multi-year. Data suggest few false positives, including sites with water. Low cost allows more deployments for a fixed budget and makes vandalism less of a concern. Activity levels depend on BCDR placement and bat behavior, and should only be compared within sites, while patterns can be compared across sites. Site specific correlation of activity levels to emergence counts may be possible. Data from gray bat sites revealed systematic variation in activity patterns within and across sites suggesting dispersal of juveniles to caves across the region in mid-July.

Exploring the Pitfalls and Potential of White-nose Syndrome Treatment Strategies

Pattavina, Pete (Pete_pattavina@fws.gov)

U.S. Fish and Wildlife Service, RG Stephens, Jr. Federal Building, 355 East Hancock Avenue, Room 320, Athens, GA 30601

Since its discovery nearly fifteen years ago, the Eurasian fungus *Pseudogymnoascus destructans* (Pd) , the pathogen responsible for the bat disease white-nose syndrome, continues to spread across North America, killing millions of native bats naïve to its effects. The U.S. Fish and Wildlife Service spends approximately $5 million annually through its white-nose syndrome program to understand host-pathogen dynamics and perform disease surveillance, and more recently to develop expanded field and laboratory trials for control of *Pd* to increase survivorship of infected bats. This is an overview of recently funded research and field trials, as well as a discussion of the constraints that face wildlife and land/karst managers in the treatment of animals and subterranean habitats that have sensitive ecosystems and experience significant recreational visitation.

Collaborative Monitoring Strengthens Macro-Scale Assessments of White-Nose Syndrome Impacts for North American bats

Reichard, Jonathan—corresponding author

Cheng, Tina L.[1]; Reichard, Jonathan D.[*2](jonathan_reichard@fws.gov); Coleman, Jeremy T.H.[2]; Weller, Theodore J.[3]; Thogmartin, Wayne E.[4]; Reichert, Brian E.[5]; Frick, Winifred F. [1]; and the NABat Colony Count Consortium

[1]Bat Conservation International, Austin, TX; [2]US Fish and Wildlife Service, Hadley, MA; [3]US Forest Service, Pacific Southwest Research Station, Arcata, CA; [4]US Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, WI; [5]US Geological Survey, Fort Collins Science Center, Fort Collins, CO

In order to understand macro-scale population dynamics and impacts from landscape-level perturbations, monitoring at broad scales is imperative. White-nose syndrome (WNS) has caused severe, local declines and extirpations in several species of hibernating bats throughout North America. We used annual winter counts to assess bat colonies in caves and mines to examine macro-scale impacts of WNS on North American bat species. Data were contributed by state, provincial, and federal biologists who have worked with cavers and other partners to count bats in winter colonies for decades. We used winter count data for five species of hibernating bats collected in the US and Canada at over 200 sites across 25 states and provinces, and spanning 23 years from 1995-2018. Our study highlights the strength of macro-scale assessments that can only be derived from broad-scale monitoring efforts, and which are needed to implement greater global, national, and state/province-level protection for the most impacted species. The North American Bat Monitoring Program (NABat) was initiated in 2015 as the first broad-scale coordinated effort to monitor bat species across North America. Winter and summer colony estimates are an important part of NABat, and the consolidation of historic and current count data with standardized acoustic detection information through a uniform geographic framework will allow for robust analyses of bat population trends. NABat also provides an opportunity and support for local managers of cave and karst ecosystems to participate in the program and bolster understanding of the bat species using these habitats.

The importance of a Karst Club in High School.

Richardson, Hailey Raye*[1] (hrichardson@wcs.k12.va.us); Ahn, Steve[2]; Napier, Aaron[2]

[1]32152 Plymouth Court, Apartment 500 C, Damascus, VA; [2]Holston High School, 1308 Monroe Road, Damascus, VA, 24236

The Karst Club has been at Holston High School for five years, giving students access to experience and knowledge of caving that is not available in most schools. Holston High School is located in a small Appalachian town, and like much of Appalachia, suffers from a lack of opportunity and economic prosperity. Talented youth tend to leave the area due to the perception that there is very little for them here. Appalachia's riches lie in the landscape and literally in the land. Unfortunately, many students take the region's natural gifts for granted and miss out on an important reason to keep their own natural gifts in the area. The Karst Club is an organization whose goal it is to connect students with the wonders of the land around and below them in an effort to fully develop the next generation. Past and present students will discuss karst experiences, the impact of the club on their own lives, the philosophy of the leadership and development aspect of the club, and the issues involved in running such a club in a high school setting.

The Presence of Pharmaceuticals and Personal Care Products in Appalachian Karst Waters

Schmidt, Diana*[1] (dianafs@vt.edu); Ahn, Steve[2]; Napier, Aaron[2]

[1]Virginia Tech Lee Hall, 570 Washington St SW, Blacksburg, VA 24061; [2]Holston High School, 21308 Monroe Rd, Damascus, VA 24236

In recent years, studies have found that pharmaceuticals and personal care products (PPCPs) are present in surface and groundwater around the globe. The effects of these compounds in aquatic ecosystems are widely unknown. The purpose of this study was to determine the presence of PPCPs in agricultural and urban-impacted karst hydrology. Water samples were collected from karst waters, including cave streams and springs, from across Southwest Virginia and underwent solid phase extraction (SPE) and UPLC-MS/MS analysis. Overall, 40 out of 140 unique compounds were positively identified with each site having between 5 and 23 compounds. Urban-impacted sites demonstrated a higher number of identifiable PPCPs than agriculturally impacted sites. These findings demonstrate a correlation between direct human influence and PPCP presence in karst waters and have significant applications in future karst water quality studies.

Create Quick 3D Working Maps with CaveWhere

Schuchardt, Philip (vpicaver@gmail.com)

cavewhere.com

Cave, where? Visualize caves here, with CaveWhere. CaveWhere is an open-source, cross-platform (Windows, MacOS, and Linux) software package for managing and visualizing cave data. Inspired by the need to generate working maps on caving expeditions, CaveWhere can warp and render 2D paper sketches in 3D. Once sketches of surveyed caves are uploaded in CaveWhere, CaveWhere can export high-resolution working maps for drafting, from any viewing angle. Additionally, CaveWhere can produce plan view maps, and create a projected cave profiles along user specified planes from in-cave running profiles. Survey projects can utilize CaveWhere's lead database for visualizing and maintaining an active lead list, delineating areas of the cave not completely explored and requiring attention. CaveWhere seamlessly imports or exports data from existing survey projects that use various other cave survey software, including Survex, Walls, or Compass. Its flexibility and interoperability allow CaveWhere to enhance visualization of a cave's geometry without time-consuming modeling and drafting, facilitating rapid evaluation of cave resources and their potential. Consider integrating CaveWhere into your cave survey toolkit for both new and existing survey projects.

Lava Beds National Monument: Test Site for Mars Missions
(On Becoming the Prototype Lava Beds IntraGalactic Monument for Mars)

Seiser, Patricia E. (patricia_seiser@nps.gov)

Lava Beds National Monument, PO Box 1240, 1 Indian Well Hqts, Tulelake, CA 96134

How does one test instrumentation to be used in the lava caves of Mars? Why, you come to Lava Beds National Monument, of course. The NASA BRAILLE (Biological and Resource Analog Investigations in Low Light Environments) Team has selected Lava Beds as an analog environment to study, evaluating technology and methods that will be used to look for life or geochemical evidence of life on Mars. The BRAILLE team is characterizing the microbial life in caves, the nutrients in rock and water that feed them, and the biominerals produced by the microbes living there. In addition, they are using the NASA Ames Research Center's test rover, directed by a remote surface team who set up a Mission Command Center at Park Headquarters, to conduct autonomous robotic life-detection and mapping operations in Valentine Cave. These exercises help the team test mission operations concepts that may one day help NASA in planning similar activities for a Mars mission.

Cherokee Syllabary in Howards Waterfall Cave, Georgia: Conservation and Interpretation of Cultural Resources in a Southeast Cave Conservancy Preserve.

Simek, Jan – corresponding author

Carroll, Beau Duke[1]; Cressler, Alan[2]; Alvarez, Stephen[3]; Belt, Tom[4, 5]; Simek, Jan*[6] (jsimek@utk.edu)

[1]Tribal Historic Preservation Office, Eastern Band of Cherokee Indians, Cherokee, NC, 28713; [2]1790 Pennington Place SE, Atlanta, GA 30316; [3]Ancient Art Archive, 165 Laurel Drive, Sewanee, TN 37375; [4]Cherokee Language Program, Western Carolina University, Cullowhee, NC 28723; [5]United Keetoowah Band of Cherokee Indians in Oklahoma, Tahlequah, OK 74464; [6]Department of Anthropology, University of Tennessee, Knoxville, TN 37996

In 2014, Alan Cressler visited Howards Waterfall Cave in Georgia at the request of the Southeast Cave Conservancy (SCCi). A group had offered to clean "graffiti" from the cave's walls and the SCCi, owners of the cave since 1991, wanted to be sure there was nothing of historical significance on the walls. There was. In a side passage, Cressler saw inscriptions that he recognized as Cherokee syllabary, a Native American writing system invented in the early 19th century by the brilliant Cherokee intellectual Sequoyah. He sent photographs to Simek, who confirmed the identification. Almost immediately, Simek contacted the Eastern Band of Cherokee Indians, and they, along with the US Fish and Wildlife Service, The Conservation Fund, and Transcontinental Gas Pipeline Company, provided funds to build a gate protecting the syllabary passage. Cherokee scholars and others began documentation, translation, and study of the inscriptions, including high-resolution 3D photogrammetric modeling of the syllabary passage by the Ancient Art Archive. Howards Waterfall is one of several caves in the area now known to contain Cherokee inscriptions. The writings in Howards Waterfall Cave concern powerful religious activities that occurred in the seclusion of the cave. The main panel bears a signature in syllabary that has also been documented at Manitou Cave to the south, suggesting the same person participated in ceremonies in both caves. Cherokee syllabary is one of the great intellectual inventions in early American history, and its presence in Howards Waterfall Cave requires special protection and conservation as a rare and significant cultural resource.

The Northeastern Cave Conservancy, Inc. an Introduction.

Simmons, Robert*[1] (president@necaveconservancy.org); Folsom, William[1]

[1]The Northeastern Cave Conservancy, Inc. PO Box 254, Schoharie, New York 12157

The Northeastern Cave Conservancy, Inc. (NCC) was founded in 1978 to receive Knox Cave, a former commercial cave in upstate New York from the owner Dr. Delisa, who wished to see the cave preserved, but no longer wanted to retain ownership for liability purposes. In 1975, a large icefall off the side of the entrance sinkhole resulted in one fatality and one crippling injury to two college students that were entering the cave. The NCC was established with a small Board and managed this single cave property. In 1999, the NCC expanded its purview to become a membership based multi-preserve entity, operating at a 501 (c) (3) land trust with a nine-member board of directors and four officers running the day-to-day business of the conservancy. Since 1999, the NCC has added an additional eight preserves (with two more on the way) containing 15 known caves throughout east-central New York State. The NCC is seeking properties in the other states within its mandate (New England and New Jersey) and provides outreach, education, and assistance to groups, land owners, regulatory agencies, and other land trusts throughout the northeastern US. This talk will review the history of the NCC - its preserves, outreach efforts, and milestones in our growth - and take a candid look at issues (and answers) we have encountered along our way.

Initial Report, Outside Influences on Caves Project, New York.

Simmons, Robert*[1] (president@necaveconservancy.org); Ingalls, Morgan[1]; Berger, Mitchell[1]

[1]The Northeastern Cave Conservancy, Inc. PO Box 254, Schoharie, New York 12157

The Northeastern Cave Conservancy, Inc. (NCC) has begun a multi-part assessment to better inform management of its caves in the wake of white-nose syndrome (WNS) and the listing of the Northern Long-Eared Bat as threatened. The NCC owns nine cave preserves containing sixteen caves, many of which serve or served as bat hibernation sites. The New York Department of Environmental Conservation (DEC) has performed bat surveys at NCC caves, within the constraints of budgets and manpower. WNS is believed to have reduced bat populations in the caves of the northeast by greater than 90%. Unauthorized winter incursions into NCC caves are suspected, which could result in disturbance of remnant and recovering populations. To assess the caves as hibernation sites, obtain environmental data and determine if unauthorized winter incursions occur, a basic data collection effort is progressing to monitor the entrances to the caves through the fall swarming, winter hibernation and spring emergence periods, monitor the presence of light to assess unauthorized visitation and collect long-term subsurface temperature and humidity conditions and variability. NCC obtained a grant through the DEC Conservation Partnership Program, administered by the Land Trust Alliance to purchase instrumentation, and support equipment. The purpose is to assess the suitability of NCC caves as recovery sites and inform management options. 2018-2019 data will be shared, as will materials and methods used, logistical issues and an overview of a science project using a volunteer workforce will be discussed, as will future plans.

Addressing the Taxonomic Impediment:
Updating the Biodiversity of Subterranean Pseudoscorpions in Virginia

Stephen, Charles*[1](cdr.stephen@gmail.com); Orndorff, Wil[2]; Malabad, Tom[2]; Kosič Ficco, Katarina[2]

[1]Department of Biological Sciences, Auburn University, Auburn, AL; [2]DCR Natural Heritage Karst Program, 8 Radford Street, Suite 102A, Christiansburg, VA 24073

The study of pseudoscorpions in Virginia's ca. 4000 caves began in 1884 with the publication of the first species endemic to the Commonwealth's caves: *Apochthonius coecus*. Presently 18 troglobiont or troglophilic species have been described from Virginia, with potential for three additional troglobiont species that have been collected but not described. Twelve species are endemic to Virginia with strongly localized distributions, and five species are not endemic but have their type locality within Virginia. An example of the latter is *Hesperochernes mirabilis*, the subterranean pseudoscorpion with the largest known distribution. Efforts began to compile a list of subterranean pseudoscorpions in 1908; the most recent list was published in 2012. A taxonomic impediment has greatly slowed documenting the biodiversity of these enigmatic arachnids. Although specimens potentially representing new species continue to be found, four decades have passed since a new species was described. Here, we summarize the known literature and provide new data we collected in Virginia caves from 2016-2019. We are beginning to address the taxonomic impediment through identifying whether our specimens represent new records of known species or are new to science. Several specimens we have collected show strong promise for being new species endemic to Virginia and will be described in the near future, along with an updated species-level checklist and a taxonomic key. Our results highlight the urgency of developing and maintaining taxonomic expertise and associated professional services to support efforts to conserve the unique subterranean environments of the Appalachian region and beyond.

How Many Rangers Does it Take to Change a Lightbulb?
The Saga of Upgrading an Aging Cave Lighting System

Truebe, Sarah A. (struebe@azstateparks.gov)

Kartchner Caverns State Park, 2980 S. Highway 90 / P.O. Box 1849, Benson, AZ 85602

Kartchner Caverns, located in a state park in Arizona, underwent an upgrade of its 20-year old lighting system in early 2019. When the original lighting was installed, Kartchner Caverns's lighting system was high-tech and advanced, with the goal of making the lights unnoticeable in the cave, quietly fading on and dimming off in the background, with no lights obviously visible to the visitors when avoidable. The entire system was run off of a computer, with each press of a button in the cave changing lights across rooms the size of a football field. Lighting technology has advanced substantially in the last 20 years; bright and responsive LED lighting is now the standard compared to incandescent and halogen bulbs. Kartchner Caverns staff have refrained from upgrading to LEDs, despite the obvious benefits of heat reduction and ability to alter the light spectrum to diminish the growth of algae, because dimming technology was insufficient to capture the original appearance of the tours. Recent events at the cave made it necessary to upgrade, however, and here I discuss the challenges and benefits of our recent upgrade to LEDs and new lighting control system. I will also discuss challenges related to electrical codes in show caves, with the hopes of sparking discussion on the topic more generally. Finally, I will share cave microclimate monitoring data showing the almost immediate impact of upgrading all lights to LEDs.

High-Resolution Measurements of Cave Air pCO_2 in the Context of 30 Years of Cave Air Carbon Dioxide Data

Truebe, Sarah A.[*1] (struebe@azstateparks.gov); Webster, Kevin D.[2]

[1]Kartchner Caverns State Park, 2980 S. Highway 90 / P.O. Box 1849, Benson, AZ 85602; [2]Planetary Science Institute, 1700 E. Fort Lowell Rd. Ste #106, Tucson, AZ 85719

Carbon dioxide (CO_2) concentrations in natural caves trend higher than atmospheric concentrations. CO_2 sources include dripwater degassing, soil CO_2 diffusion, organic matter decay, geothermal outgassing, and tourism. Removal of CO_2 appears to be primarily by mixing with atmospheric air. Cave ventilation is thought to be controlled by air density, driven by seasonal changes in temperature/pressure relative to cave air. Kartchner Caverns is a show cave in southern Arizona that exhibits annual CO_2 concentration cycles with highest temperatures in August/September and lowest in January. Kartchner Caverns hosts 134,000 visitors every year and holds multiple tours per day that could influence CO_2 concentrations at higher frequencies than the routinely collected biweekly monitoring data. Thus, we used a single Omega AQM-100 CO_2 meter to obtain high-resolution snapshots of CO_2 concentrations in four key locations. Although our data are as yet insufficient to comment on the impact of tourism, we observed a strong correlation of ventilation with average surface wind speed, but not with temperature or pressure as measured by an on-site weather station. This suggests that an air density gradient created by temperature/pressure variability may prime the cave air system, but the addition of wind allows for more significant ventilation than by simple diffusion alone. Windiness may increase in southern Arizona with global change, which may lead to more frequent or deeper ventilation of Kartchner Caverns, suggesting active management of humidity levels into the future may be necessary.

Using Bat Guano from Cave Springs Cave in Northern Alabama to Reconstruct Moisture Patterns Throughout the Holocene.

Tsalickis, Alexandra[*1] (azt0074@tigermail.auburn.edu); Waters, Matthew[1]; Campbell, Joshua[2]; Medina, Martin[3]

[1]Crop, Soil, and Environmental Science Department, 201 Funchess Hall, Auburn University, Auburn, AL; [2]Entomology Department, 952 Bee Lab Rd, Auburn, AL;[3]Geology Department, 2050 Beard-Eaves Coliseum, Auburn University, Auburn, AL

The need to understand long-term precipitation patterns in the southeast United States is of great concern considering population increases, climate change, and other environmental stressors. Current management strategies are typically based on modern records spanning the past ~50 years, forecasting models based on these records, and dendrochronology records spanning the past hundreds of years. One scientific approach to tracking moisture regimes over millennial timescales which has received very little attention to date is the study of bat guano deposits in cave systems. Guano deposits are common in multiple caves systems throughout Alabama and the southeastern US, and their isotopic compositions have been shown to track moisture and precipitation. Here, we present a 9,000-year record of moisture and rainfall periods based upon stable isotopes ($\delta^{15}N$, $\delta^{13}C$, $\delta^{2}H$) in a guano core collected from Cave Springs in Priceville, Alabama. Moisture was inferred from carbon and nitrogen stable isotopes showing alterations between C_3 and C_4 plant abundance indicating changes from cooler to warmer environments, respectively. Deuterium was measured from bulk guano and used as an evaporation/precipitation measurement. Results were compared to other paleoclimate records such as pollen from lake sediment cores and provide evidence for the Holocene Climatic Optimum, as well as periods of changing precipitation throughout the Holocene. This study suggests that future research investigating guano deposits from caves can provide a unique and long-term record of local paleoclimate.

Optimizing Karst Feature Characterization:
Integrating Non-invasive Geophysical Methods with Invasive Geotechnical Sampling

Vaughan, Johanna (jovaughan@daa.com)

Draper Aden Associates, 2206 S Main St, Blacksburg, VA 24060

Undetected karst features may be inadvertently damaged by land disturbance and result in further development or alteration, as well as substantially increased land development costs (e.g., removing rock pinnacles, sinkhole mitigation). Invasive geotechnical sampling provides valuable but discrete data for karst features and may be cost-prohibitive or constrained by physical, ecological, and regulatory barriers. Non-invasive geophysical methods combined with geotechnical sampling is beneficial for characterizing potential karst, which can help protect features from unintended impacts of development by evaluating their spatial subsurface extents. Specifically, electrical resistivity imaging combined with invasive sampling provides direct observational data and reliably extrapolated interpretations. Remote sensing (e.g., electrical resistivity imaging) acquires non-destructive data related to subsurface physical property distributions for rendering subsurface mapping. For example, georeferenced electrical resistivity profiles calibrated by a nominal drilling data-set can cost-effectively elucidate subsurface bedrock topography and karst expression. Combining electrical resistivity imaging and invasive drilling data with precise Global Positioning Systems (GPS) and Light Detecting and Ranging (LiDAR) data, via industry-standard platforms such as AutoCAD, ArcGIS, or Google Earth, provides powerful and cost-effective risk-management and enhanced resource protection for karst environments.

Karst in Perry County

Vaughn, Denise Henderson[*1] (denisevaughn@littlepinecreek.net); House, R. Scott[*2]

[1]#5 State Route NN, Mountain View, MO 65548; [2]Cave Research Foundation, 1606 Luce St., Cape Girardeau MO 63701

Perry County, Missouri has over 700 documented caves, including four of the state's five longest caves. The intense surface karst includes vast areas of subterranean drainage with numerous sinkholes, caves, and springs. The caves host great biodiversity, including the federally endangered grotto sculpin (*Cottus specus*). The chief threat to the sculpin is water quality and habitat loss. The City of Perryville is a rapidly growing community with numerous industries. Over time, the city has taken steps to ensure that cave systems under the city and surrounding areas have their watersheds improved and protected. Caving organizations and other non-governmental organizations have helped as have state and federal agencies. Today, while there is much more to be done, the outlook for the grotto sculpin and the caves in general is improving. This educational video shows how human adaptations to the karst environment have changed over time. In the nineteenth century, residents used sinkholes as sewers and later as trash receptacles. In recent times, the local community has come to value water quality in the cave streams and springs, and has turned a controversy over the endangered grotto sculpin into proactive efforts to prevent sediment and agricultural chemicals from entering groundwater and caves.

The Southeastern Cave Conservancy in 2019

Walkey, Christine (christine.walkey@scci.org)

Southeastern Cave Conservancy, Inc., PO Box 250, Signal Mountain TN 37377

Southeastern Cave Conservancy, Inc. is the largest land conservancy in the world dedicated solely to the protection of cave and karst ecosystems. SCCi protects wild caves throughout the southeast through conservation, education, and recreation. Our new Director of Education and Outreach, Christine Walkey, will talk about how SCCi achieves its mission. Specific topics include the history and structure of SCCi as a 501(c)3 non-profit organization, current holdings, recent acquisitions, and organizational updates. SCCi has added the Charles B. Henson Preserve at Johnson's Crook, a 2,400-acre property in Rising Fawn, GA. It has also added the Elroy and Marilyn Daleo Cave Preserve, an 85-acre property in Hart County, KY. The Daleo Preserve has an entrance to the Roppel Cave section of Mammoth Cave, the longest known cave on earth. In 2019, SCCi grew by receiving a grant through the Lyndhurst Foundation to support two new staff members, a Land Use Manager and the Director of Education and Outreach. Education has expanded to include the Project Underground curriculum, which is receiving an updated book, website, and educator workshops.

The Virginia Cave Board: A Unique Resource for Karst Management in Virginia

Weberg, Meredith*[1] (merecaver@yahoo.com); Lindeman, Steve*[2]; Doctor, Daniel H.[1]

[1]Virginia Cave Board, VDCR, 600 East Main Street, 24th Floor, Richmond, VA 23219-2094; [2]The Nature Conservancy, 146 East Main Street, Abingdon, VA 24210

This presentation provides an overview of the Virginia Cave Board (VCB), a unique advisory body on cave and karst issues in Virginia. The VCB was established in 1979 to conserve and protect the state's caves and karst landscapes, and to advocate for the wise use of karst resources. All members are volunteers appointed by the governor. The VCB is an independent advisory body administered by the Virginia Department of Conservation and Recreation (DCR) Natural Heritage Program. The VCB and the Natural Heritage Program's karst team work both together and independently to protect and to educate the public about Virginia's biologically rich and environmentally sensitive caves and karst. Although the VCB is non-regulatory in nature, it has nonetheless been influential in advising on development projects in karst regions by producing documents such as guidelines for *Karst Assessment Standard Practice*, *Frequently Asked Questions (FAQs) About Natural Gas Transmission Pipelines Through Karst Terrains*, and *A Resident's Guide to Sinkholes*. The VCB hosts Virginia Cave Week, which promotes an understanding of Virginia's caves and the surrounding karst. The VCB also established the Virginia Cave and Karst Trail, highlighting a number of publicly accessible sites across the state that enable citizens to learn more about Virginia's cave and karst ecosystems, and publishes the *Virginia Cave Owners' Newsletter* at least once per year. All the aforementioned documents are available online at the VCB website: https://www.dcr.virginia.gov/natural-heritage/cavehome.

New River Cave Preserve: A Study of the Spelunker and his Tools

Woelk, Taren*[1] (tmwoelk@vt.edu); Scales, Stewart[2]

[1]New River Cave Preserve, 1202 Snyder Ln, 1400F, Blacksburg, VA, 24060; [2]Geography Department, Virginia Tech, 115 Major Williams Hall, 220 Stanger St, Blacksburg, VA, 24061

The purpose of this study was to establish usage rates and patterns at the National Speleological Society (NSS) New River Cave Preserve and to use this information to evaluate the safety practices of users and potential threats to the cave's resources. It is well known to previous preserve managers and NSS cavers from local grottos that the cave has a history of heavy visitation by inexperienced cavers. In recent years, the cave's location has become well publicized on the internet, which has likely increased the number of un- or underprepared visitors. In order to research these questions, we collected data from trail camera images from 9/15/2018-3/15/2019. From these images, we derived the length of a trip, the number of participants, their clothing quality, the presence of helmets and lights, and weather conditions. Furthermore, we reached out to Preserve Managers of other NSS properties to ascertain possible similar conditions of heavy usage by non-cavers at other preserves. From this analysis, we determined that the majority of visitors to the New River Cave Preserve do not have proper equipment during any time of year, but during the cold winter months are more likely to be properly clothed for caving due to outside weather conditions. The vast majority of these visitors seem to be college students. Additionally, we found that many large trips (exceeding 15 persons), sometimes multiple trips on the same day, visited the cave during bat hibernation season. The results of this study suggest that both the users and cave resources are at risk of harm and we recommend a waiver and permit system be introduced, and potentially a gate.


RASS
RICHMOND AREA SPELEOLOGICAL SOCIETY

The Northeastern Cave Conservancy, Inc.

Preserving Caves and Karst Since 1978

The Northeastern Cave Conservancy, Inc. (NCC) is a not-for-profit corporation committed to the conservation, study, management, and acquisition of caves and karst areas having significant geological, hydrological, biological, recreational, historical, or aesthetic features.

To these ends, the NCC combines the resources and expertise of affiliated cave explorers, educators, scientists, landowners, and conservation officials.

NECaveConservancy.org

KARST WATERS INSTITUTE

The Karst Waters Institute is a nonprofit institution whose mission is to improve the fundamental understanding of karst water systems for professionals and the public.

Goals:

Engage professionals in small conferences and workshops to advance karst science.
Increase recognition and publication of karst science
Foster development of karst professionals
Communicate and disseminate information to the public

Please visit karstwaters.org for many free resources and publications, and to learn more.

THANK YOU NCKMS 2019 SPONSORS!

DCR
Virginia Department of Conservation & Recreation

Real Science, Real Solutions
ESI
Environmental Solutions & Innovations, Inc.
ENVSI.COM

Draper Aden Associates
Engineering • Surveying • Environmental Services
Lasting Positive Impact

RASS
Richmond Area Speleological Society

Terracon

Cave Conservancy Foundation

Luray Caverns
Eastern America's Largest & Most Popular Caverns
A U.S. Natural Landmark

The Nature Conservancy
Protecting nature. Preserving life.

UVA WISE

EDWARDS AQUIFER AUTHORITY

Appalachian Cave Conservancy

Speleobooks

National Cave and Karst Research Institute

Ben Walls Photography * Fabric etc... * Mountain Sports Ltd. Misty Mountain Designs * Mountain Empire Comics * The Answer Inner Mountain Outfitters * Lost World Caverns * Sinking Creek Pottery